Compressed Air Magazine

Vol. 40, No. 7 | London - New York - Paris | July, 1935

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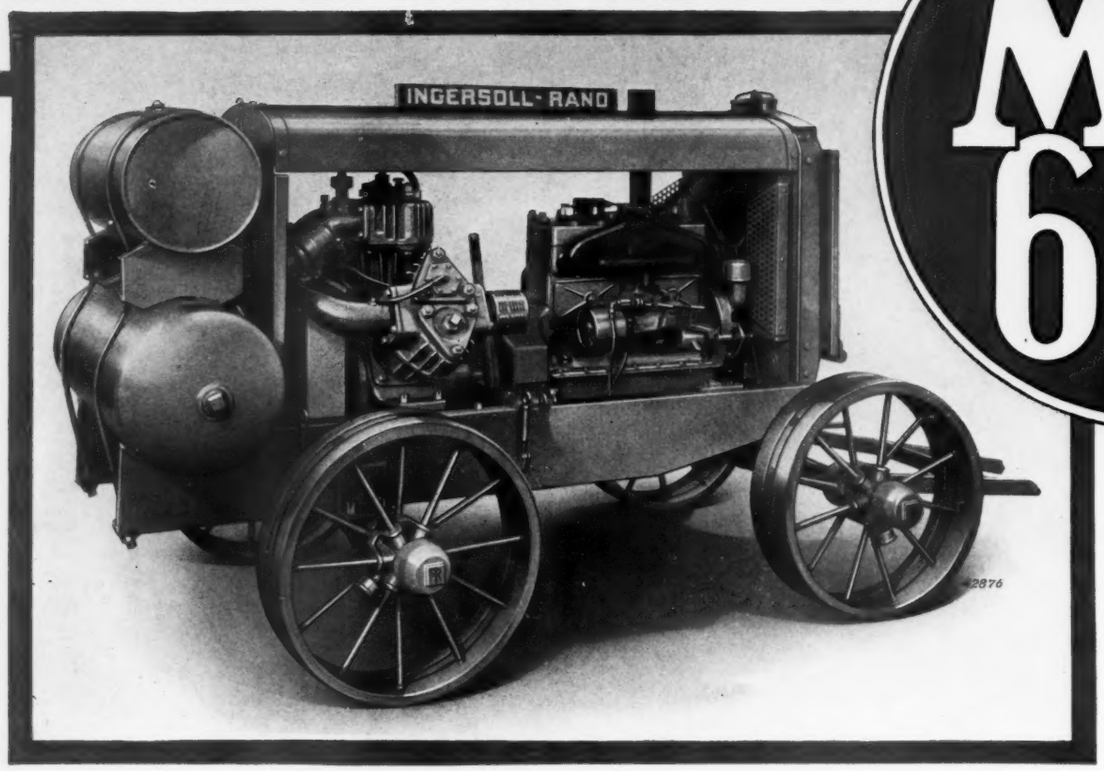

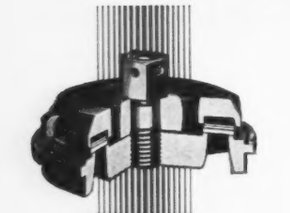

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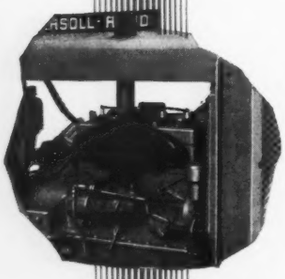

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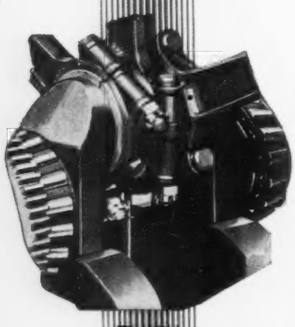

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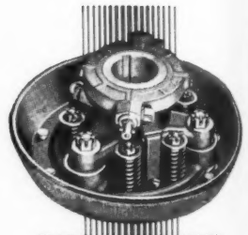

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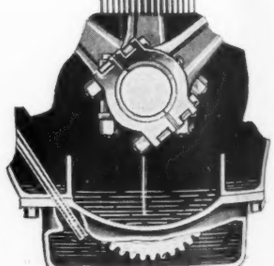

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Compressed Air Magazine

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C. H. VIVIAN
Editor

A. M. HOFFMANN
Assistant Editor

European Correspondent
LINWOOD. H. GEYER
144 Leadenhall Street
LONDON, E. C. 4

Canadian Correspondent
F. A. McLEAN
620 Cathcart Street
MONTREAL

Business, Editorial and Publication Offices
PHILLIPSBURG, N. J.

Advertising Office
11 Broadway
NEW YORK CITY

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The World's Largest Distillery

C. H. Vivian

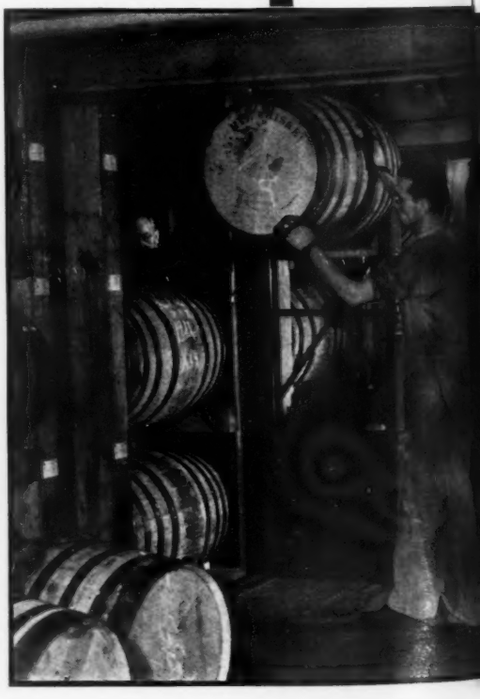
GENERAL VIEW OF DISTILLERY

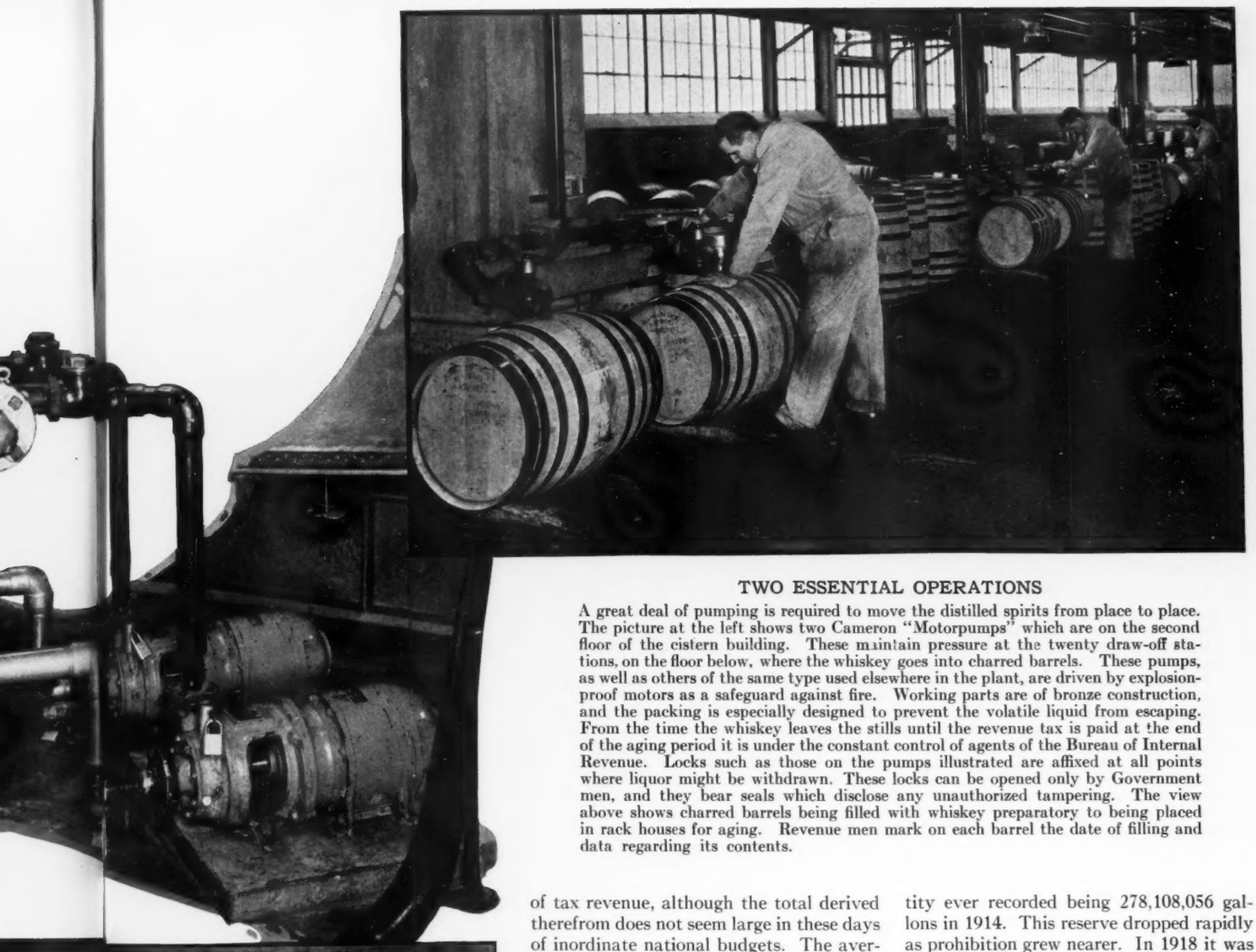
Built in nine months, this plant is the world's largest whiskey producer. The picture was taken from the grain elevator, and shows the power house in the right foreground. Left of the buildings is the Illinois River which, through canal connections, affords waterway transportation to the eastern seaboard.

WHEN prohibition was repealed the United States had only a small number of legitimate distilleries. Breweries were still standing in various parts of the country and were in such condition that they could be rehabilitated quickly and at relatively low cost, but plants for producing whiskey and other spirits were few in number. Consequently, one of the first and most notable effects of repeal was to set in motion a construction program of considerable proportions. Outstanding among the new distilleries erected is that of Hiram Walker & Sons, Inc., at Peoria, Ill. With a capacity for distilling 100,000 proof gallons a day, it is the largest plant of its kind in the world. This one distillery pays the Federal Government as much as $121,000 a day in revenue taxes.

Before describing the processes by which whiskey and other spirits are made in this plant, it may be of interest to present a few salient facts regarding the distilling industry as it existed prior to the legal dry era which began in January, 1920. Official figures of the Bureau of Industrial Alcohol show that the annual production of whiskey during the period 1900 to 1918 averaged 70,000,000 gallons. During one of those years, 1911, it exceeded 100,000,000 gallons, and in only one year did it fall below 50,000,000 gallons. Whiskey was by far the leading spirituous-liquor product of the nation. Brandy held second place; but never was more than 9,500,000 gallons of it made in any one year, and the average for the period under consideration was between 6,000,000 and 7,000,000 gallons annually. In 1912 the production of gin reached its high mark of 5,756,666 gallons, but normally it was about half that figure. The output of rum averaged 2,000,000 gallons annually, and never went above 3,000,000 gallons.

Distilleries were important buyers of grain. In a single year the farmers of the nation sold for liquor-making purposes as much as 33,973,268 bushels of corn, 6,250,989 bushels of rye, 4,440,315 bushels of malt, 33,775 bushels of oats, 32,197 bushels of wheat, and 3,972 bushels of barley. The liquor was an important source





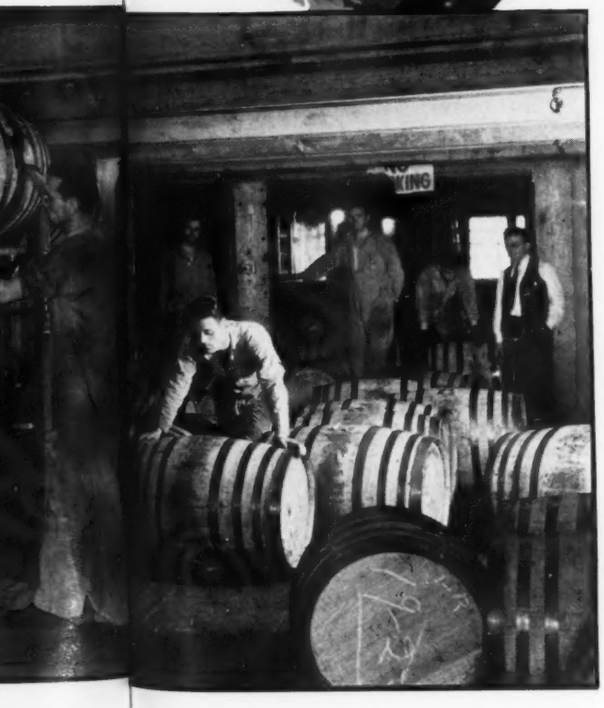
TWO ESSENTIAL OPERATIONS

A great deal of pumping is required to move the distilled spirits from place to place. The picture at the left shows two Cameron "Motorpumps" which are on the second floor of the cistern building. These maintain pressure at the twenty draw-off stations, on the floor below, where the whiskey goes into charred barrels. These pumps, as well as others of the same type used elsewhere in the plant, are driven by explosion-proof motors as a safeguard against fire. Working parts are of bronze construction, and the packing is especially designed to prevent the volatile liquid from escaping. From the time the whiskey leaves the stills until the revenue tax is paid at the end of the aging period it is under the constant control of agents of the Bureau of Internal Revenue. Locks such as those on the pumps illustrated are affixed at all points where liquor might be withdrawn. These locks can be opened only by Government men, and they bear seals which disclose any unauthorized tampering. The view above shows charred barrels being filled with whiskey preparatory to being placed in rack houses for aging. Revenue men mark on each barrel the date of filling and data regarding its contents.

of tax revenue, although the total derived therefrom does not seem large in these days of inordinate national budgets. The average tax return to the Government from whiskey was $150,000,000 a year. During war times, when the rate rose from $1.10 to $6.40 per gallon, the total mounted sharply, and reached $353,737,044 in 1919.

It should be borne in mind that the whiskey was matured for varying periods before it was marketed, so that production and consumption did not run parallel. The record consuming year was 1917, when 83,500,000 gallons were sold. The average annual consumption from 1900 to 1919 was 55,000,000 gallons. There was usually about a 4- to 5-year supply of whiskey in bonded warehouses, the greatest quantity ever recorded being 278,108,056 gallons in 1914. This reserve dropped rapidly as prohibition grew nearer. In 1918 it was 140,721,821 gallons, and a year later it was only 63,942,931 gallons. Normally, this country exported only from 100,000 to 350,000 gallons of whiskey annually, but increasingly greater amounts were sent abroad during this period. In 1920, the first year that the dry edict was in effect, nearly 4,000,000 gallons were exported. This movement continued until, in 1925, the stocks in bonded warehouses were below 30,000,000 gallons.

The only whiskey released for consumption in this country during prohibition was that needed for medicinal purposes. Compared with the use prior to 1920, the quantity was very small, ranging from 1,000,000 to 2,000,000 gallons annually. The Commissioner of Industrial Alcohol exercised supreme control over withdrawals, and he also had the power to authorize distillation to meet the demand for legal purposes. However, it was not until the end of 1929, when warehouse stocks were reduced to 15,000,000 gallons, that he allowed distilling operations to be resumed. The quota for 1930 was set at 1,998,947 gallons; in 1931 it was 2,435,631 gallons; and in



IN A RACK HOUSE

Arriving at one of the six aging warehouses, the barrels of whiskey are put in racks and remain there until nature has changed the raw congeners into aromatic elements. Each warehouse has a capacity of more than 70,000 barrels. To assist in the process and to curb evaporation, the air in the buildings is conditioned and humidified. To be bottled in bond, whiskey must be aged at least four years in charred-oak containers.

1932 it was 1,711,028 gallons. The authorized output for 1933 was 2,500,000 gallons; but when it became evident that the constitutional dry amendment was to be voted invalid, this was increased to 10,000,000 gallons. As whiskey designed for medicinal use must be aged at least four years, the 1930 production was not available for withdrawal from warehouses until 1934.

The effect of prohibition upon the legalized liquor industry is well known to all; but its full import can be set forth statistically. In 1901 there were 1,506 registered distillers in the country, and 1,258 of them were operating. By 1919 there were but 154, of which only 72 were operating. Even though national prohibition did not become effective until 1920, a great many states had previously outlawed liquor, and it was this movement that caused distilleries to close. In the year 1918 alone their number decreased from 301 to 154, or nearly 50 per cent. During the prohibition era there was, of course, no legal distillation of whiskey until the close of 1929. By 1933 there were only six distillers registered in the entire United States. One of these had two plants, making a total of just seven distilleries in readiness for producing whiskey.

With this background, it is easy to understand why the distilling industry had virtually to be rebuilt from the ground up when repeal came. The prevailing trend in that direction has been towards the establishment of a relatively small number of large distilleries. It is now plainly evident that we shall probably never again have as many individual plants as existed at the beginning of the century.

The Irish are credited with having originated whiskey, and the word by which we know it was derived from the Celtic *usquebaugh*, meaning "the water of life." Today whiskey is of many kinds, and each nation has its characteristic variety. The greater portion of American whiskey has always been made from corn and rye. It was formerly heavy bodied, for the reason that the apparatus and methods of distillation were capable of producing only that type of liquid. Recent improvements in equipment and advances in the scientific control of processes have, however, made light-bodied whiskies possible, and these are rapidly gaining in favor throughout the country.

Whiskey is defined by the Government as an alcoholic distillation of fermented grains. Its flavor, aroma, and other characteristics depend upon the kind and the proportion of grain used, the process of distillation, and the duration of maturing or aging. Bourbon whiskey, whiskey which has always led in American consumption, is distilled from fermented mash of grain containing not less than 51 per cent of corn and at not more than 160 proof. If we substitute rye for corn in the proportion just given, the product is rye whiskey. Scotch whiskey is made from barley malt, and owes its distinctive flavor to the fact that peat is used as fuel in the roasting of the barley.

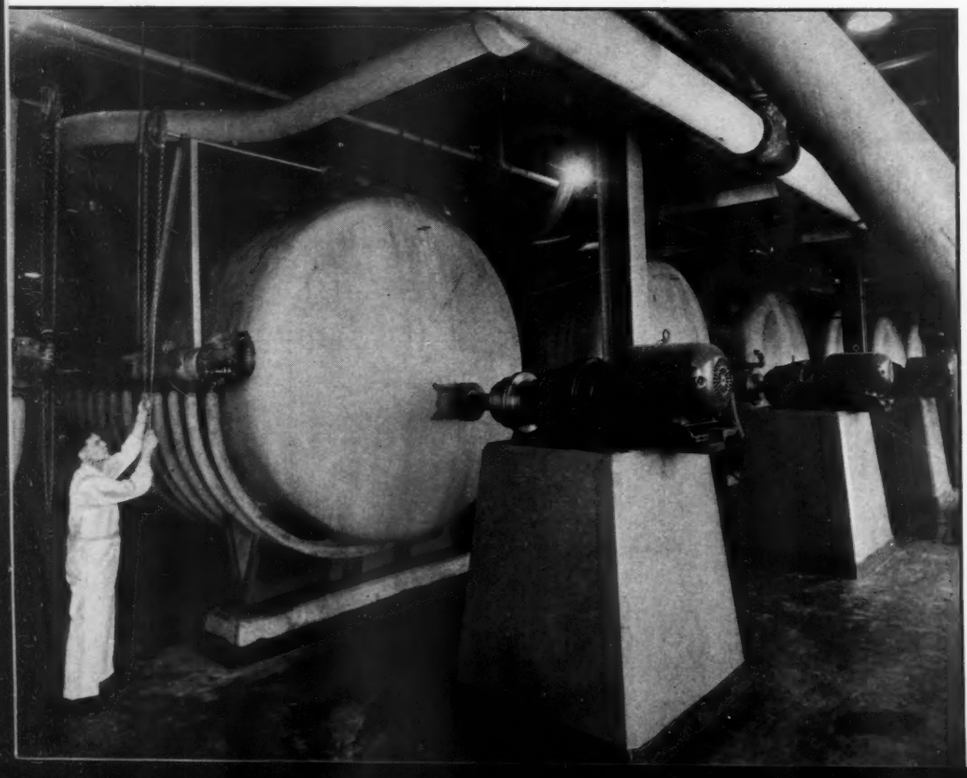
Mention was made in the preceding paragraph of distillation at 160 proof. Each degree of proof indicates one-half of 1 per cent of alcohol by volume. Thus 160 degrees of proof means 80 per cent alcohol by volume. Legally, the product of distillation is whiskey when the degree of proof is not more than 160. Above 160 degrees of proof the product becomes neutral whiskey, neutral spirits, or alcohol.

From the foregoing it is plain that in the distillation of whiskey there is carried over from the fermented grain alcohol plus other ingredients. It is the latter which give whiskey its characteristics and which differentiate it from spirits and alcohol. Technically, they are known as congeners. They consist essentially of substances which the chemists call total acids, esters, higher alcohols, aldehydes, and furfurol. These congeners impart to whiskey the rawness of taste which it possesses when first distilled. Under the influence of aging, however, the congeners are converted into aromatic substances, and by reason of their transformation the whiskey acquires mellowness and smoothness.

As sold, whiskey is usually of 85 to 100 proof. If it has been distilled at a higher proof, which is the usual practice, the reduction in alcoholic content is effected by adding distilled water. Straight whiskey is whiskey of a particular type to which no other whiskey or spirits has been added. A blend of straight whiskies is just what the name implies, whereas a blended whiskey contains not only one or more straight whiskies but generally neutral spirits, neutral whiskey, or other kinds of whiskey. It does not follow that a blended whiskey is undesirable or unpalatable. Practically all Scotch whiskey, for example, is a combination of straight whiskies and neutral spirits. By blending, it is possible to maintain a uniform flavor and aroma which become characteristics of a certain variety or brand of whiskey.

The name Hiram Walker has long been identified with whiskey, but until the repeal of prohibition the company had never distilled liquor in the United States. The founder of the business, Hiram Walker, Sr., was a native American. In 1857 he started a flour mill just across the Canadian border from Detroit. Like many millers of those days he used surplus grain for distillation, and thus began the industry which still bears his name. He established the Town of Walkerville, Ont., and directed his Company's operations there for 30 years. Following his death in Detroit in 1899, his grandsons continued to run the business until 1926, when it was combined with another leading firm of Canadian distillers, Gooderham & Worts, Ltd. One of the prominent Hiram Walker brands, Canadian Club Whiskey, stood first among the whiskies imported to the United States during the years immediately prior to prohibition.

The reasons that led to the selection of Peoria for the new distillery were the same as those that had previously attracted distillers there in sufficient number to make it the principal center of whiskey production in America before liquor was



GRAIN COOKERS

To render its starch content soluble, grain meal, mixed with well water, is cooked in these insulated vessels by means of 70-pound steam, the temperature being maintained well above the normal boiling point at atmospheric pressure. At the conclusion of the cooking period the mash is partially cooled by drawing a vacuum on the vessel. Malt is then added, and the mixture is withdrawn into a drop tub, where it remains until the malt has converted the starch into grain sugar.

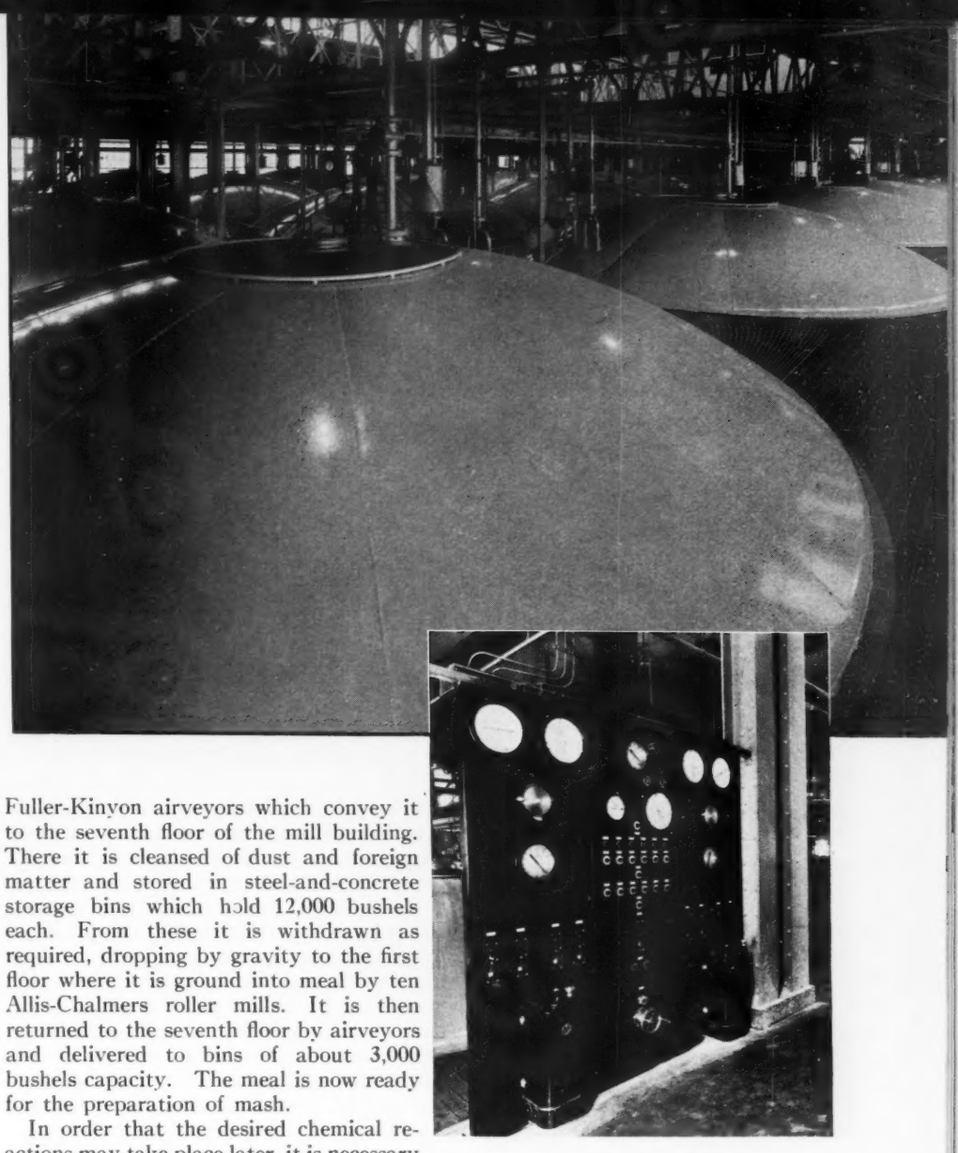
legally banned. It is said that in those days more revenue taxes were paid in Peoria than in the states of Pennsylvania, Maryland, and Kentucky combined, despite the fact that all the latter were important whiskey producers.

Peoria has five assets from the distiller's standpoint. First and foremost it has an ample supply of cold water of high purity. Anywhere a well is drilled in the area it will tap water which has a year-round temperature of about 52°F. As vast quantities of water are used in a distillery, much of it for cooling purposes, this is an important item. Moreover, Peoria is in the heart of an important grain belt; inexpensive coal is close at hand; fifteen railroads touch the city; and it is a central point for the distribution of manufactures. Aside from these major considerations. Peoria provides adequate intelligent labor, having been ranked first in literacy among communities of its class. With a population of 104,000, it stands second to Chicago among Illinois cities. In and close to it are located more than 450 manufacturing establishments which turn out some 1,500 products.

The Hiram Walker Distillery, with its equipment, represents an investment of more than $7,000,000. It is the second plant of its kind to occupy the site. The Great Western Distillery, which once paid revenue taxes of $22,500,000 in one twelve-month, operated there for years. Prohibition sounded its doom, and a decade or so ago the plant was scrapped. Exceptionally fast progress was made in constructing and equipping the new distillery. In September, 1933, the site was untouched: nine months later the plant was running. Smith, Hinchman & Grylls of Detroit were the architects and engineers, and Bryant & Detwiler Company, also of Detroit, were the general contractors.

As it is practiced in this ultra-modern establishment, distilling differs materially from older methods. Once upon a time whiskey-making was considered something of an occult art. There were traditions that in order to make good liquor the moon had to be right, and things of that sort. Proprietors of stills closely guarded their secret formulas; and when they died the business sometimes died with them because they failed to leave behind them the all-important directions for procedure. In contrast, distilling is now carried on under close engineering supervision. A research laboratory determines the formulas, and a plant control laboratory sees that they are carried out. Essential operations are regulated as to time, temperature, pressure, and other factors, and performances are registered upon gauges and recording instruments.

The grain used in this plant is of four kinds: corn, rye, rye malt, and barley malt. It reaches the distillery in railroad cars or trucks. It takes only a matter of minutes to unload a car of grain with Fuller-Kinyon airveyors which convey it to the seventh floor of the mill building. There it is cleansed of dust and foreign matter and stored in steel-and-concrete storage bins which hold 12,000 bushels each. From these it is withdrawn as required, dropping by gravity to the first floor where it is ground into meal by ten Allis-Chalmers roller mills. It is then returned to the seventh floor by airveyors and delivered to bins of about 3,000 bushels capacity. The meal is now ready for the preparation of mash.



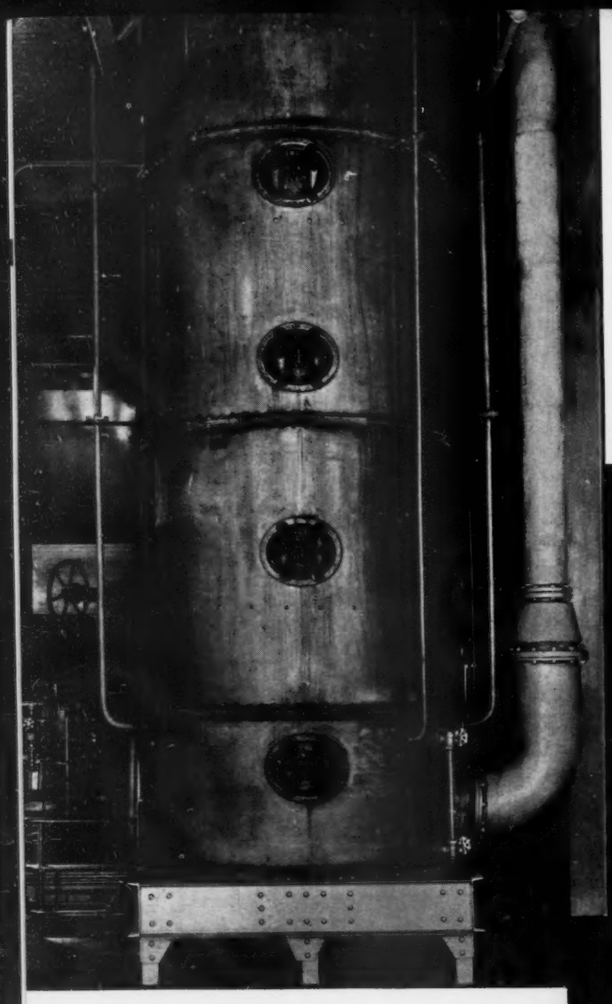
FERMENTERS

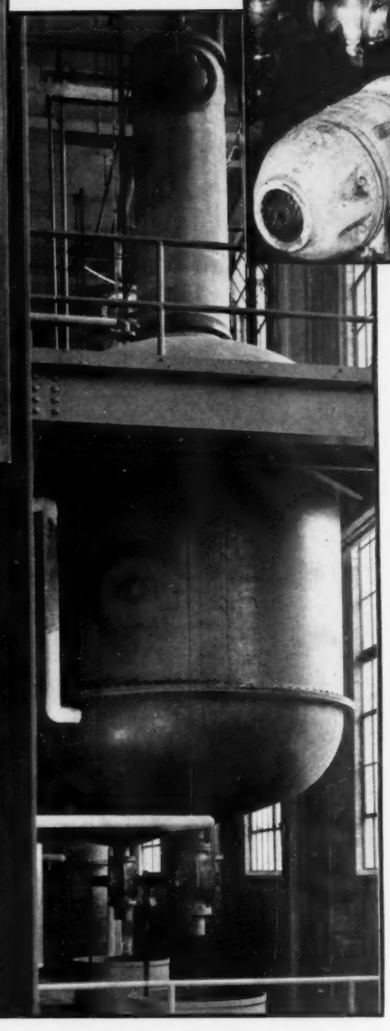
In the upper picture are shown the tops of some of the 24 huge tanks in which yeast effects the fermentation of the grain mash, breaking down its sugar content into ethyl alcohol and carbon dioxide. Close control of the temperature is exercised by means of pneumatically actuated appliances. One of the panels on which the operating conditions are registered is seen in the inset.

In order that the desired chemical reactions may take place later, it is necessary first to cook the grain to render its starch content soluble. This is done in eight closed, horizontal, cylindrical vessels, insulated to confine the heat, each having a capacity of 13,258 gallons. Measured amounts of grain and cold water are introduced and cooked by steam under a pressure of 70 pounds to the square inch and at a temperature well above the normal atmospheric boiling point. Following the cooking, a vacuum is drawn on the cooker to cool the contents quickly. Malted grains are then added, and the mixture is allowed to fall into what is known as a drop tub on the floor below.

The mash remains in the drop tub until the diastase, which is contained in the malt, converts the soluble starch of the cooked grain into grain sugar. Much depends upon the proper consummation of this process; and before the mash is further treated it is sampled and checked in the laboratory. Upon being approved, the mash is pumped through a tubular cooler. This consists of banks of double pipes—the mash moving through the interior section while cold well water flows counterwise through the outer, surrounding section. It is necessary that the temperature of the mash be lowered because a certain degree of heat would kill the action of the yeast which is added in the subsequent operation.

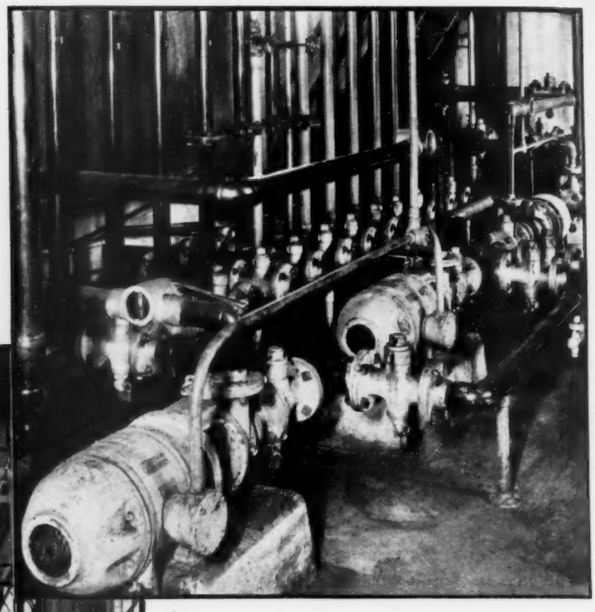
The cooled mash is next pumped into a fermenter. There are 24 of these huge upright vessels, each of which has a capacity of 117,442 gallons. Distillers yeast, which is prepared in another department of the distillery, is added in the proportion of some 8 to 10 parts to every 1,000 parts of mash, together with sufficient well water to fill the tank to the working level. The mash is allowed to ferment for 72 hours. The reaction generates heat, which is removed by circulating cold water through pipes, the temperature being automatically controlled to within 2°F. During the fermentation, the yeast attacks the grain sugars, splitting them





STILLS

A continuous-type whiskey still is shown above. In this many-chambered column, rising steam extracts the alcohol and flavoring congeners from the grain as the fermented mash or "beer" descends by stages. This apparatus can produce 25,000 proof gallons of whiskey a day. Gin stills (right) are different in appearance. Neutral grain spirits are distilled in these, together with aromatic flavorings which impart to the product its distinctive taste and aroma.



PUMPS IN HIGH-WINES BUILDING

The product of the stills goes to the high-wines building where it is passed upon by the testing committee to determine whether it is up to standard. If approved, it is pumped to tanks in the cistern building by the Cameron "Motor-pumps" shown above. They are 100-gpm. units each driven by an explosion-proof motor that is built integrally with the pumping elements and housed in the same casing.

into ethyl alcohol and carbon dioxide. The carbon dioxide is led off from the top. During the warmer months of the year it is used to manufacture dry ice in a plant on the premises that is under the direction of the Liquid Carbonic Corporation. The product of fermentation goes under the name of distiller's beer. From the fermenters it drops into flumes which convey it to beer wells, where it remains until a still is ready to receive it.

Whiskey stills are of several varieties. The first apparatus was merely a pot, from which sprang the name "poteen" by which illicit Irish whiskey has been known for generations. Pot stills, usually modifications of the original type, are still used for making certain kinds of whiskey. From a production standpoint they possess disadvantages, as they require emptying, cleansing, and recharging after each run. About 1830, the Coffey patented, continuous-type still made its appearance, and has since been improved.

The modern continuous still is an upright, cylindrical column divided into many chambers by perforated plates. The mash is introduced at the top and drops progressively downward through the series of compartments. Distillation is effected by live steam, which enters at the bottom and rises through the chambers in direct contact with the mash. The spent mash is removed at the bottom of the still. The chamber still combines some features of both the pot and the continuous types. It consists of several chambers disposed vertically. The beer charge is placed in the uppermost division and subjected to partial distillation, after which it is dropped, by means of a lever, into the next space below. This progression continues, a new charge of mash being introduced into the top chamber as soon as it has been emptied.

The pot still permits such large quantities of congeners to pass over into the distillate that the resulting whiskey requires a long period of aging—at least five to seven years—to bring about their transformation into aromatic substances. Pot-still liquor must be redistilled, and even then it is impossible to obtain a product of more than 140 degrees proof. What has just been stated also applies to the chamber still, though in lesser degree. The modern continuous still gives a whiskey of higher proof. Moreover, it can be controlled as to pressure, temperature, etc., so that the volume of congeners passing over can be regulated. It is therefore possible to produce a whiskey that will become palatable and smooth after a relatively short period of aging.

In the Hiram Walker plant there are two continuous-type whiskey stills, each with a capacity of 25,000 proof gallons a day. They are automatically controlled, and the nature of the output can be varied through a wide range, according to whether the resulting liquor is designed for blending or for straight whiskey, or how long

IN THE BOTTLING PLANT

The five production lines shown above have a bottling and packaging capacity of 30,000 cases of whiskey every seven hours. The bottles are cleaned and filled mechanically; but labels and revenue stamps are applied by hand. These operations are performed by neatly clad girls, a group of whom is shown below. Immediately after it is filled, each bottle passes through a lighted compartment, where it is inspected through a large magnifying glass (right).

it is to be aged. There are also two continuous-type stills with a capacity of 25,000 proof gallons daily that can be used for making whiskey, neutral whiskey, or neutral spirits; one 3-chamber still for the production of heavy-bodied rye whiskies; and two gin stills with capacities of 15,000 proof gallons.

The product from the whiskey stills goes to a rectifying column where, in a distilling operation similar to the fractionation of petroleum, the excess of such undesirable elements as aldehydes, fusel oil, etc., is driven off. It is these heavy elements that impart harshness to whiskey and that, if allowed to remain, would add to the aging period required to assure a desirable product.

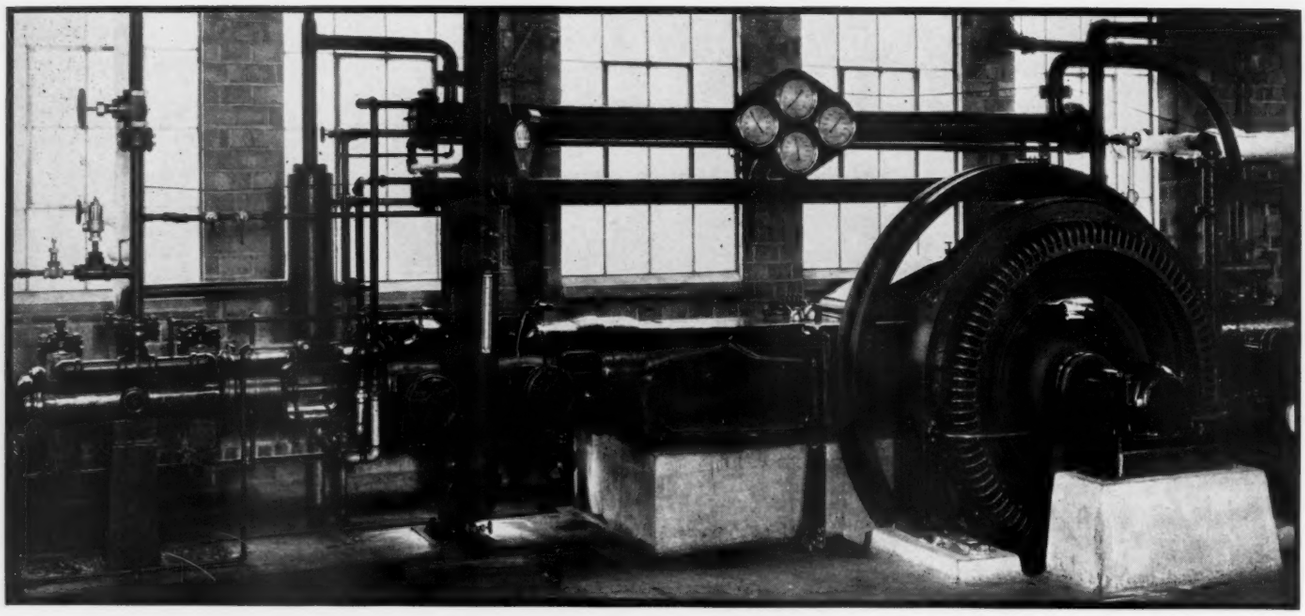
From the rectifying columns the distillate is pumped to tanks in what is known as the high-wines building. Each day the run of the preceding day is there passed upon by the testing committee. Its taste and aroma are compared with those of controlling laboratory specimens and standard analyses. If the plant output is found to be below standard, it is returned to the stills and converted into neutral spirits or commercial alcohol.

Approved whiskey goes to the cistern building where the proof is adjusted in conformity with Federal regulations. It is then drawn into charred barrels, each of about 50 gallons capacity, which are placed in storage warehouses, or rack houses as they are termed, for the designated period of aging. These rack houses furnish an illustration of how modern processing methods have made it possible to shorten the time that was once required in order to produce a given quality of whiskey.

Formerly there was a belief that amounted almost to a superstition that whiskey aboard ships was improved in quality by crossing the equator. Actually this was true, the reason being that the agitation of the rolling ship and the temperature and humidity prevailing in the tropics accelerated the aging process. In the Hiram Walker rack houses those atmospheric conditions are simulated by controlling the temperature and humidity of the air.

When matured whiskey is withdrawn from the warehouse the Federal revenue tax is paid at the rate of $2 per proof gallon. The liquor then goes to the rectifying plant, where it is transferred from the barrels into glass-lined tanks. If it is to be marketed as straight whiskey, the proof is adjusted; if it is to be used in making a blended whiskey, the other ingredients are mixed with it. The product, in either case, is filtered and delivered to glass-lined tanks where it awaits bottling.

Mention was made previously of two gin stills. This liquor is produced by distilling rectified spirits in a columnar chamber with various substances which impart to the drink its characteristic flavor and aroma. In making the several kinds of gin, some fifteen of these ingre-



DRY-ICE COMPRESSOR

Carbon-dioxide gas which comes off the fermenters is one of the principal by-products of the whiskey-making process. Through an arrangement with Hiram Walker & Sons, Inc., the Liquid Carbonic Corporation is utilizing this gas in the making of dry ice. It is known as a peak-load plant—that is, it is operated only during the warm-weather months when the demand for dry ice exceeds the latter's regular supply. The gas is compressed to approximately 1,200 pounds per square inch by this 4-stage, Ingersoll-Rand Type XNH machine which is driven at 164 rpm. by a G-E., 300-hp., synchronous motor. There are two Norwalk presses for compacting the "snow" into blocks. The capacity of the plant is 30 tons a day.

dients are employed. The most important ones are juniper berries, coriander seed, cassia bark, and orange peel. Virtually all these flavorings are secured from abroad.

Comparatively slight variations in the distilling process, or in the strength or the quantity of the flavoring materials, will produce perceptible differences in the taste and the aroma of the gin, and for that reason very close control is exercised over its manufacture. The laboratory determines the strength of all the flavorings, and they are proportioned in the stills accordingly. As in the case of whiskey, the senses of taste and smell are the best guides to the quality of the product. Testers daily compare the current output with the laboratory sample, which it is supposed to match. Gin is not aged before marketing; but it does have the peculiarity of sometimes acquiring a change in taste and odor a week or so after it is made. Testing is therefore continued for several days after it comes from the stills. Unless it is approved, it is sent back for redistillation.

The bottling department of the plant consists of ten conveyor lines along which the containers move while the essential operations are performed. Bottles are delivered in the same cartons to which they are returned, after filling, for shipment. Prior to their filling they pass through a machine for cleaning. As they are all new bottles that have been inspected at the glass plant which produced them, they seldom contain any contaminating matter other than a little box-board dust. Cleaning is effected by first creating a turbulence in the bottles with compressed air at 60 pounds pressure and then exhausting this by drawing a vacuum on them. Laboratory tests show that this procedure is more effective than washing. Compressed air for this purpose is furnished by an Ingersoll-Rand Class ES-1 compressor. In order that the air may be entirely free from oil the machine is designed so as to operate without lubrication.

The bottles are filled by machines of the vaccum type. These automatically introduce the correct volume of liquor and will not fill bottles that have defects such as cracks, pinholes, chipped areas, etc. From the filling machines, the bottles go to a capping device which automatically seals them. They then pass along a conveyor belt on either side of which sit rows of neatly uniformed girls who inspect them and affix the correct labels and revenue stamps. Next they proceed to packers who place them in cartons which are mechanically sealed. On their way to the shipping platform the cartons are weighed.

In addition to the service just mentioned, compressed air has various other uses in the plant. One of its important functions is that of actuating control devices in regulating temperatures, pressures, and flows. It is employed for emptying tank cars of liquids and for cleaning motors, gratings, floors, etc. It operates drills and pneumatic tools in construction and maintenance work. Electric tools are not used in some sections of the plant because of the fire hazard presented by the high alcoholic content of the liquors in course of manufacture.

Space does not permit a description of the power house, which is modern in every respect. Its boilers are fired with pulverized coal, of which from 300 to 400 tons are consumed every 24 hours. In addition to furnishing process steam, this station generates the electricity that is required for the different plant operations. Water, which is consumed in quantities as great as 12,000,000 gallons a day, is pumped from five wells.

Principal by-products of the distillery are carbon dioxide and fusel oil. The use of the former in the making of dry ice has been mentioned, and fusel oil is in industrial demand as a solvent in cellulose lacquers, as a flotation reagent in ore-reduction mills, as a base for making perfumes, and as the starting point in one synthetic-rubber process. The spent grain from the stills is dried and converted into stock feed, special equipment for this purpose being installed.

In addition to the spirituous liquors mentioned, the plant produces varying quantities of commercial alcohol. Plans are in formation for the manufacture of a line of cordials which will utilize some of the spirits now being made there. The new distillery employs approximately 1,200 persons of whom nearly 200 are college graduates, most of them from technical schools.

SUNSET ON PORCUPINE LAKE

This placid body of water, which lends an air of repose and beauty to the busy mining area, saved many lives during the disastrous fire of 1911. With the flames racing through the trees at express-train speed, it offered the only haven for the panic-stricken populace.

Thirty Years of Canadian Mining

Porcupine - Part 2

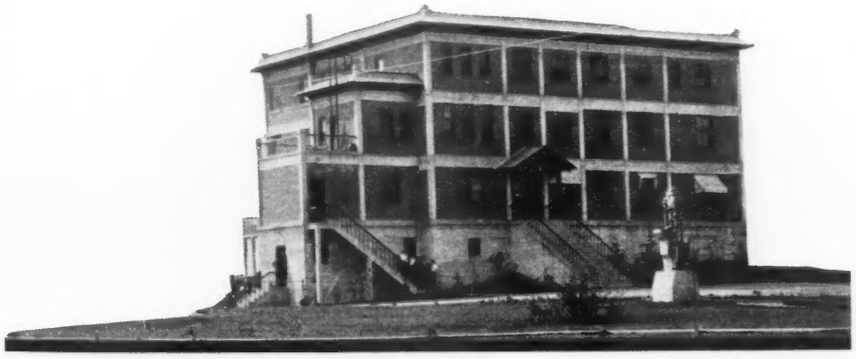
R. C. Rowe

THE fire of 1911 was a catastrophe of such proportions as to stagger any community, and it speaks worlds for the tenacity and strength of purpose of the people in the region that within 24 hours proper organizations were caring for the injured and homeless and preparations were underway to rebuild what had been so suddenly and fearfully destroyed. In fact, the seared ground in the towns of South Porcupine and Pottsville was not cool before men were rigging shelters from warped galvanized-iron sheets salvaged from the wreckage, and in a few days the work of rehabilitation was well underway.

As was to be expected, the disaster delayed the development of the camp. Under ordinary circumstances, Porcupine would have been producing gold in 1911, less than two years after its discovery. We are likely to pride ourselves today upon the speed with which new camps are brought to production; but had Porcupine not been devastated by the fire it would have set a record that we would still find hard to beat. When it is remembered that it was unknown until late in 1909—too late for any work to be done that year—and that it was without transportation facilities, production in 1911 would have constituted a remarkable accomplishment. As matters turned out, it was delayed until 1912; but, at that, it was an exceptional showing of speed and efficiency that has been almost forgotten.

During the remainder of 1911 work proceeded rapidly, and it was during that time that McIntyre-Porcupine Gold Mines, Limited, was incorporated to operate the claims found by Sandy McIntyre. In March of 1912 a 50-ton stamp mill went into action on this property. The mill superintendent was R. J. Ennis, whose name has become synonymous with Porcupine, and who is now the general manager of the mine which has grown from a daily capacity of 50 tons to 2,000 tons.

Early in 1912 underground workings of the Hollinger Gold Mines had reached 400 feet, and the gold content of No. 1 Vein averaged $49.30 per ton at 200 feet. That was more than 2-ounce ore—something else that we have got into the habit of forgetting about Porcupine. When we recall that fact, however, we do not cease to wonder that the eyes of the world were directed toward the new camp. A 300-ton mill was in operation that employed coarse grinding, stamping in cyanide, and tube-milling, followed by table concentration with amalgamation of table concentrates and cyanidation of table tailings and amalgamation residues. On November 1, Hollinger Gold Mines payed the first dividend of the camp, and the value of the bullion recovered that year amounted to $933,682, while the ore treated averaged $21.44 per ton.



A RELIC PRESERVED

The office building of the Hollinger Consolidated Gold Mines, Limited, at Timmins, Ont., as it looked in 1925. Mounted on a concrete pedestal in front of the structure is the Tremain steam stamp which was the first unit to be installed in the Hollinger mill.

FREIGHTING TO PORCUPINE

Porcupine was developed in the era of the horse. It was far removed from a railroad, and the movement of equipment and supplies constituted a herculean task. Roads were mostly bad in the summer, and the major portion of the freighting was consequently done during the winter months. Vastly different conditions prevail today. Tractors do the heavy work, and airplanes are invaluable carriers.

The Dome Mine went into production in March of 1912 with a 300-ton mill. In this plant the ore passed through the 40-stamp mill and over amalgamation plates to Dorr classifiers the sands of which were reground in tube mills and fed over plates and corduroy blankets. Tailings were cyanided. This mill was built by Henry Hanson, who later went to the Homestake and is now living in Toronto.

About the middle of the year the Vipond also started to operate with a 100-ton plant. In this case grinding was accomplished with ball mills and tube mills and was followed by amalgamation. The plant, however, was closed that autumn. Thus we find that during 1912 the camp had swung well into production and had paid its first dividend. The Town of Timmins was incorporated the same year and reached reasonable dimensions.

It was at that time that the district encountered labor troubles which finally culminated in a strike during the latter part of 1912. This held up work to some extent and was accompanied by violence and blood-letting. It was not ended until 1913; but after that the camp settled down to steady progress. A number of properties became active, the most notable being those close to the producing mines. Among these we find the Jupiter, which was taken over by the Drummonds of Cobalt and was directed by R. W. Brigstocke. Later, the Jupiter became a part of the McIntyre-Porcupine interests, and is now one of the main properties of that company. The Pearl Lake Mine also was acquired by the same company. In 1912 the Porcupine Crown built a mill that was put in operation in 1913. M. W. Summerhayes, who is now general manager of the Wright-Hargreaves at Kirkland Lake, was in charge of the property which was controlled by the Crown Reserve of Cobalt. This mine was subsequently taken over by the Vipond, but not until after it had been closed down for some time. Work was also being carried on at several other properties.

III

Which Is Largely A Summary

"All the dreams that have flown since that day;
All the hopes in that time passed away."
—Bret Harte.

IT IS a somewhat unfortunate circumstance of mining that after a new district has passed through its discovery period its history becomes a recital of those events which go to make up progress. Into that progress, which finally culminates in an established industry, enters the work and effort of a number of men; but the infinite detail which goes to make up the accomplishment can have no place in a story of this kind. We can only look at results.

In accordance with the natural order of events, the history of Porcupine from 1913 resolves itself into a somewhat placid paean of steady development. By 1914 the tides of extreme optimism were subsiding, and true perspectives were beginning to assert themselves. The pioneer stalwarts had started to move on to other fields, and the camp settled down to that process of elimination, consolidation, and technical advance that is characteristic of any gold area once it gets to the producing stage.

As we have already said, it is not possible to give details in a general review of this nature, but some account of the expansion of the leading properties is necessary in

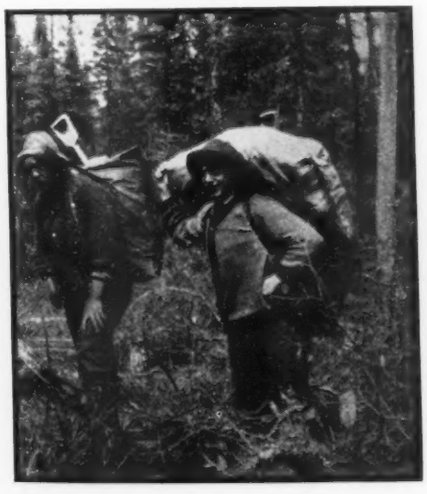
PACKERS ON THE TRAIL

Scenes such as these were typical of the Porcupine days. Prospectors were largely their own burden bearers, and the range of their operations was limited by the strength of their backs.

TWENTY-TWO YEARS AGO

Time has wrought many changes in the appearance of two of Porcupine's great mines since these pictures were taken in 1913. The view at the right shows the Dome Mine which now spreads out over more acres than are within the compass of this photograph. The surface plant of the McIntyre-Porcupine still retains a general similarity to the one seen below, but it has been considerably expanded.

order that the importance of the camp may be appreciated. In the case of the Hollinger, it may be recorded that the treatment tonnages were gradually increased from 300 to 6,000 tons per day. In 1916, Hollinger Consolidated Gold Mines, Limited, was formed, and the new company took over a number of claims until its holdings consisted of 560 acres. Now its underground workings have reached a maximum depth of 5,000 feet, and there are in excess of 200 miles of them.



Hollinger has been for years one of the world's great gold mines. Up to the end of 1933 it had produced gold to the value of $194,397,076 and paid dividends amounting to $66,102,400. Its general position today is as assured as at any time in its history, and it stands as a monument to efficient management and courageous enterprise. Into its making have gone the thought and effort of one of the finest possible technical staffs under the leadership of such men as A. F. Brigham and John Knox. V. H. Emery, the new managing director of Kirkland Lake Gold Mines, Limited, was a Hollinger man, and so was Charlie Williams, now consulting engineer and secretary of the new Canadian Metal Mining Association.

The McIntyre-Porcupine was the first company in Porcupine to adopt the all-slime cyanidation process. That was in 1913 when the original stamp mill was replaced by a 150-ton plant. Through the succeeding years this was increased to 1,500 tons per day, and in 1931 a new mill, with a capacity of 2,000 tons daily and incorporating some revolutionary features, was put in operation. This plant was designed by J. J. Denny, who was originally metallurgist for the Nipissing Mine at Cobalt and who had joined the McIntyre some years previously. In the new McIntyre mill, flotation machines were introduced between the coarse and the fine grinding of the ore. In the nineteenth annual report of the company this departure from standard Porcupine practice was described as follows:

"As soon as the ore has been reduced to, say, 60-mesh it is routed to the flotation section of the mill where a very complete separation is made between the sulphides plus the free and attached gold on the one hand and the almost barren rock on the other. The latter is immediately discarded as waste, and only the valuable portion amounting to about 15 per cent of the original ore by weight is retained in the mill circuit for fine grinding and cyanidation of the gold content. In other words, the cost of fine-grinding and cyaniding the portion that is discarded at the end of the flotation process is saved, as well as the carrying charges on such additional building and equipment as would have been necessitated by the adoption of the heretofore standard practice. Another advantage is that the treatment provided for the concentrates is under such control that a satisfactory recovery is at all times assured." It should be mentioned here that, for his contribution to the science of ore treatment, J. J. Denny was awarded the Inco Medal of the Canadian Institute of Mining and Metallurgy in 1933.

Towards the end of October, 1929, a new 4,000-foot shaft, sunk by Harry Kee, was finished by the McIntyre-Porcupine; but recently the depth of the workings has been increased to more than 6,000 feet by the sinking of a winze from the 3,750-foot level of the mine. By 1934 the company had produced gold to the value of $60,677,596 and paid dividends amounting to $12,489,162. Here again steady development has been the result of an outstanding technical staff under the leadership of R. J. Ennis, who rose from mill superintendent to general manager.

In the case of the Dome Mine there is the same story of progress to record. Mill

capacity has grown in steady stages from 300 tons per day to 1,500 tons. In 1929 the mill was destroyed by fire and a new plant was built. It also had a rated capacity of 1,500 tons, and went into production in October of 1930. The problems of the Dome have been somewhat different from those of the other major properties of the camp on account of the fact that the ore bodies occur as lenticular masses and not as veins. Consequently, they are difficult to find, and when found are equally difficult to estimate. They vary in width from 15 to 150 feet. They have been known to have a horizontal length of 600 feet and a vertical extension of 800 feet. For this reason the Dome has been threatened with depletion several times; but it is still going strong, and is generally considered to be in a better ore condition today than it ever was. To the end of 1933 this mine had paid dividends totaling $18,221,178.

The Vipond has had a somewhat checkered history; but in 1922 it came under the control of the Huronian Belt Company, formerly a British concern and the forerunner of the present Anglo-Huronian, Limited. Various acquisitions of surrounding properties were effected, and in 1926 the mill capacity was increased to 300 tons per day. Since 1923 production has been continuous.

In 1924 the well-known Coniagas Mines, Limited, of Cobalt, stepped into the Porcupine field and took over three properties: the Newray, the Goldale, and the Armstrong-Booth. The two first named had been developed to a depth of 1,000 feet, and there had been a small production from the Newray between 1913 and 1918 from a 10-stamp mill. The Coniagas interests formed Coniaurum Mines, Limited, to operate the properties, and in 1928 a 500-ton cyanide mill was put in service. This mill was the result of extensive underground work; but the venture was not successful because mill profits were unable to meet the costs of development. As the outgoings were more than the incomings the inevitable happened, and in 1929 the company was reorganized with control passing to Ventures Limited under the direction of Thayer Lindsley. Profits have been shown from that date.

This is a brief outline of the development of the main producers of the camp. That much was achieved in a very short time is evidenced by the fact that Porcupine, up to the beginning of 1934, had yielded gold to the value of $329,776,722. Of this total the four mines we have barely touched upon contributed $316,931,635 in the following proportions:

Hollinger	$189,561,748
Dome	59,450,730
McIntyre-Porcupine	60,677,596
Vipond	7,241,561

From 1928 to the end of 1933 Coniaurum produced $3,903,300; from 1913 to 1921 Porcupine Crown had an output of $2,871,847; and from 1926 to 1933 Buffalo Ankerite yielded $1,544,277.

These facts are a matter of figures; but, as must always be the case with figures, they do not tell the whole story. They do not, for instance, tell about the effect these great companies and the interests connected with them have had upon mining in Canada. The part played by Hollinger and the Timmins interests is not encompassed by mere statistics covering the production of the great Hollinger Mine. Capital from N. A. Timmins, Limited, the private incorporation of the Timmins group, has been poured into mining projects the world over, particularly in Canada. It was Timmins money that helped the San Antonio gold mine in Manitoba over a rough spot and turned disaster into success. It was Hollinger capital that tided Noranda over a difficult period in its history; and Hollinger enterprise and finance also brought the Young-Davidson Mine to the producing stage. These are only a few instances among many; but they serve to point out the fact that the Timmins interests—which rose to prominence through two great mines, first the La Rose in Cobalt and secondly the Hollinger in Porcupine—have never turned from mining but have continued to put a portion of the money they have earned back into further development of Canada's natural resources.

There is a fine principle back of this policy that should never be lost sight of and that might well be copied by others elsewhere. It has been applied by the other great mining companies in the area—companies which for years have maintained field staffs and which have spent great sums in this work of development. We can also point to the thriving communities supported by these mines, to the flourishing Town of Timmins, as added evidence of what they have done for Canada. They have promoted the science of mining and the treatment of ores in that the knowledge which they have gained in the solution of their own problems has been placed at the disposal of all the world through the medium of the technical press.

DISTRIBUTION OF PRE-CAMBRIAN ROCKS

Although they are not all ore-bearing, rocks of pre-Cambrian age are the most important carriers of metalliferous deposits in North America. They are widely distributed throughout Canada.

EARLY DRILLING SCENE

The initial development of Porcupine took place soon after J. George Leyner of Denver had made significant improvements in the rock drill, giving it increased effectiveness that contributed much to underground progress in the new camp. Shown here is a "water-Leyner" drifter drill at work in the Dome Mine in 1914.

Perhaps more important still, these great companies have been training grounds for young men, a vital thing for Canada, because men who obtained their experience in the Porcupine District are to be found in every mining section of Canada, and each has contributed something in his own way to the upbuilding of the industry there.

As we reach this point we are brought once more to the contemplation of the unfortunate fact that, while we can analyse production figures and thus assess the material benefits derived from a mining area, we can never measure with even approximate certainty the more intangible benefits. Just as Cobalt gave us vision as a people, so is Porcupine having the same effect on us; but what has been done for us in this respect will, in all probability, never be fully appreciated. Unlike Cobalt, the story of Porcupine has not yet been fully told. That district is still in the heyday of its power and productivity, and it can still look forward while Cobalt can only look backward. Yet Porcupine was the result of Cobalt, just as other areas are the result of Porcupine, which brings us to a moral with which we can close this phase of our history before turning to Kirkland Lake.

There are many who point to Lemon and Geddes, to Daigle, and those others that penetrated the area early, as the men to whom credit is due for Porcupine. In a manner of speaking they are correct: they did find Porcupine. But the writer has a simple conviction that they were the instruments of an inevitable movement. With the discovery of Cobalt and the consequent attraction to northern Ontario of men of the pioneer type, and with the promise that Cobalt indicated, the subsequent finding of the gold areas farther north was as certain as the procession of the seasons. This does not detract one single particle from the accomplishment of those that actually discovered Porcupine; but it does serve to emphasize how much this country owes to Cobalt, not so much for the riches as for the vision it gave us.

There will be some who will say that this is an exaggeration—that too much stress is placed upon this attainment of vision—that the march of progress and the settling of the land around Porcupine ultimately would have resulted in the finding of the gold. It might; but the fact remains that the old portage trail of the fur carriers passed close by the main discoveries, and for more than 200 years the feet of men trod over one of Canada's greatest assets. Yet no one found it because no one had the inspiration to look for it.

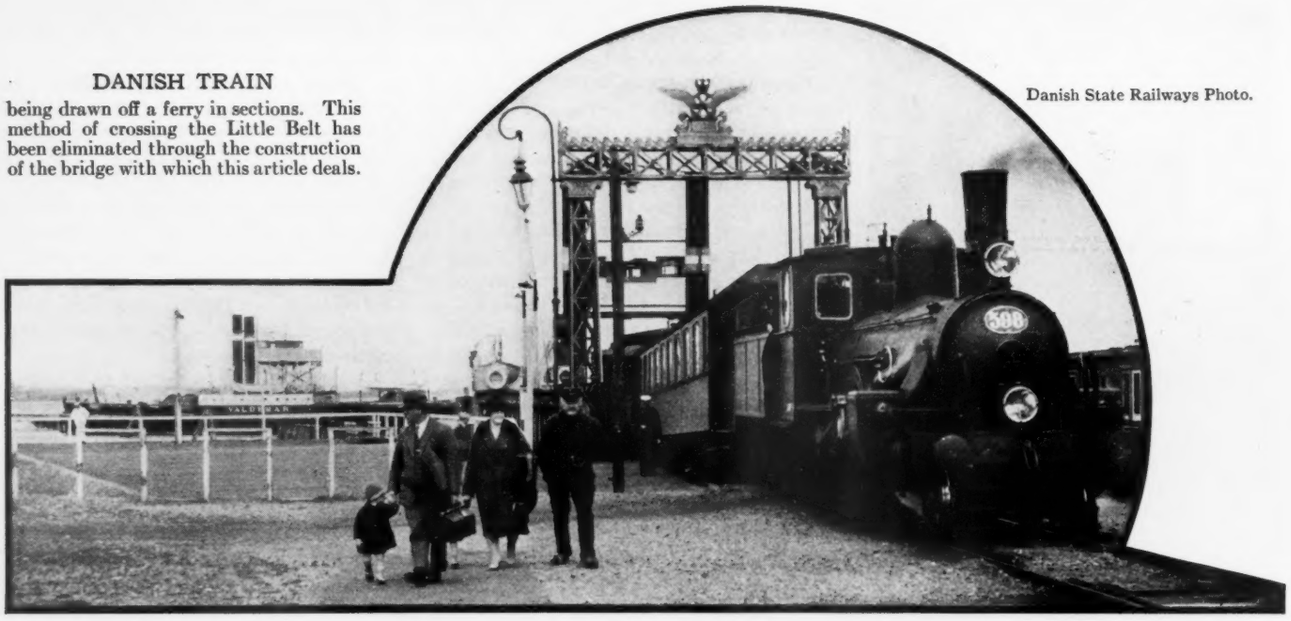
Cobalt was responsible for the vision which led to Porcupine; but in the inevitable order of things that vision would have become dim and eventually would have vanished as completely as the little winds of yesterday without something to vitalize it. That is only natural, for men grow tired, and the urge to seek sometimes weakens. Porcupine supplied that vitalizing influence—it revived the flickering light of hope; reinspired men to seek; and sent them on to fresh discoveries.

And so, as we trace the pattern of 30 years of mining history in eastern Canada we see it as a series of steps each one of which leads to the next as naturally and as easily as the chapters of an old tale perfectly told.

This is the fourth of a series of articles by Mr. Rowe. The fifth will appear in the August issue.

A VEIN OF PORCUPINE ORE

A picture taken on the 700-foot level of the Coniaurum Mine, showing a strong and well-defined quartz vein standing out sharply in contrast with the darker rocks which inclose it.



DANISH TRAIN
being drawn off a ferry in sections. This method of crossing the Little Belt has been eliminated through the construction of the bridge with which this article deals.

Danish State Railways Photo.

Sinking Deep Caissons at Normal Pressure

R. G. Skerrett

DENMARK, the oldest kingdom of continental Europe, has adopted streamlined trains to shorten the run between Copenhagen and the important North Sea port of Esbjerg which, in turn, is linked with England, France, and Holland by lines of express steamers that are much used by tourists, business people, and others in traveling to and from picturesque, industrious, and historic Denmark.

Formerly, the fast trains of the Danish State Railways required nearly seven hours to cover the distance between Copenhagen and Esbjerg, but it is now possible for these up-to-date specials to cut substantially 2½ hours from the journey—the streamlined trains and a remarkably interesting bridge that spans the waterway known as the Little Belt making this practicable.

The Little Belt Bridge was opened for service with much ceremony only recently, and obviates a car-ferry trip that, under favorable conditions, has taken fifteen minutes—not counting the time consumed in putting the train aboard the vessel at one side of the stream and running it off and reassembling it at the other side. Fogs, stormy weather, and low visibility from any cause have repeatedly slowed up the transfer from shore to shore and, on occasions, have seriously disrupted schedules. The tidal currents in the Little Belt are strong and swift; and the water route is much used by Danish and international shipping—circumstances necessitating care in traversing the stream.

After repeated agitation over a period of years, the Danish Parliament authorized the building of a bridge across the Little Belt in 1927, and in the fall of the following year the government approved the plans, prepared under the direction of the engineers of the Danish State Railways, for a combined railway and highway structure—provision being made for two tracks and for a roadway wide enough to accommodate two lines of motor-vehicle traffic. Actual construction was awarded a group of four well-known firms, with Messrs. Monberg & Thorsen, of Copenhagen, in general charge. In its finished form, the five steel spans that link the two shores have a total length of 2,706.68 feet, and with the two concrete approaches the bridge is a trifle more than 3,864 feet long. The steel crossing is of the cantilever type having a central span 721.78 feet long followed at each end by a 541.33-foot span and a 451.11-foot span. The steelwork is supported by two shore piers and by four offshore piers, while the two approaches are supported by reinforced-concrete arches.

The bridging of the Little Belt bristled with a number of engineering problems of the first magnitude. Nature interposed a number of obstacles; and it was necessary to save money and to avoid hazards by

Novel Procedure Followed in Constructing Piers for Bridging Little Belt in Denmark

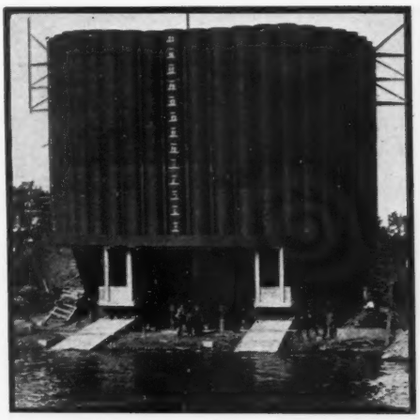
sinking the caissons for the offshore piers without employing the familiar sandhogs. To this end, much precise preliminary investigating was done to ascertain just where physical circumstances most favored a crossing, and then study was given to means and methods to determine which would best meet the conditions which could not be altered.

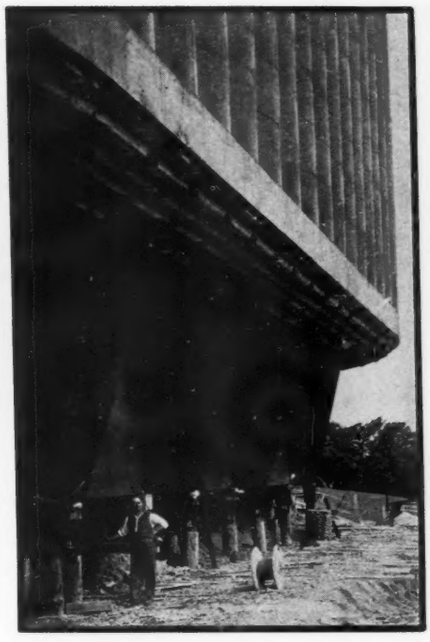
The upper currents of the Little Belt attain a maximum velocity of fully 6.71 miles an hour; and in mid-channel the waterway has a maximum depth of 131.23 feet. In cross section, the bottom slopes rapidly from each shore; and the contour of the water bed along the line of the bridge is very uneven. To assure firm foundations for the offshore piers, the sustaining caissons had to penetrate the bottom formation for a distance of not less than 28 feet—making the total depth, from the water surface to the cutting edge, as much as 132.2 feet in the case of Pier 3, placed in the deepest water.

The tidal range of the Little Belt at the bridge site is 10 feet 4 inches; and to provide an unobstructed passage for vessels using the Little Belt a clearance of 108.25 feet between the underside of the structure and the surface of the water was required. This called for piers rising 105 feet above the tideway, and meant that the caissons had to be anchored rigidly in the water bed where they could sustain the superposed dead load and at the same time resist displacement by the thrust of the strong tidal currents. Precautions also had to be taken

to prevent the currents from scouring the water bed contiguous to the piers. This was achieved by surrounding the caissons with a rip-rap of sizable bowlders.

The major problem for the engineers and the constructors was to develop caissons of a type that could be constructed on shore, launched, moved to their respective locations, and then landed precisely on the bottom of the channelway preparatory to sinking them to their ultimate depths. After giving due consideration to all other types of caissons of proved efficiency, Monberg & Thorsen decided on a departure in the art, and, accordingly, the caissons that were used in building the Little Belt Bridge were decidedly novel. To meet the conditions imposed, the cutting edge of each was so modeled that the structure stood perpendicular when the former first made contact simultaneously at all points with the sloping water bed at the given site. To bring this about, the cutting edge had to be irregular or slanting, and in that particular differed from those of previous caissons.





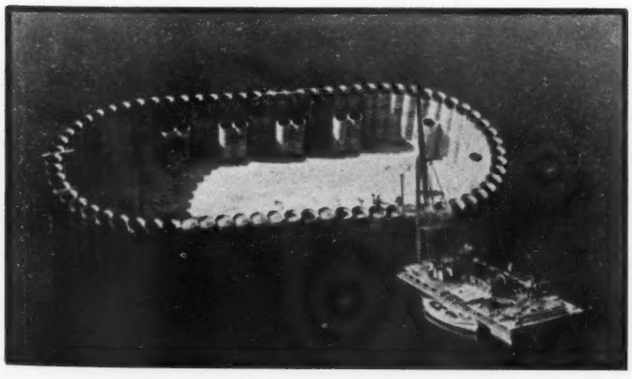
CONSTRUCTING A CAISSON

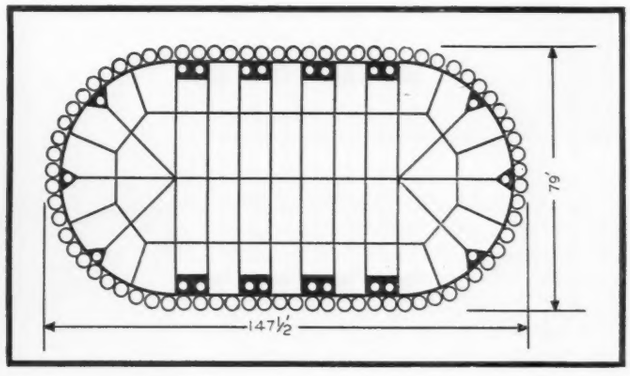
Above is one of the 7,000-ton structures ready for launching. At the right is a side view, showing some of the piles, with surmounting sand boxes, that supported the several caissons before they were lowered on to the launching ways.

The object of so adapting the cutting edges to the water bed was to facilitate setting the caissons on the bottom of the channel and holding them there against the tidal currents. But their unusual shape necessitated constructing the four caissons upside down and then reversing their positions by capsizing them after they were safely launched and in water deep enough to permit that maneuver. The launching and the upsetting of each of these great and cumbersome bodies entailed the close control of a dead weight of approximately 7,000 tons.

The hull of each caisson, as it rested on the building blocks, consisted of two parallel sides joined by two semicircular ends. This near-elliptical structure was composed of 76 vertically disposed, closely spaced tubes of reinforced concrete—each tube having an internal diameter of 3.87 feet. Immediately within the line of these tubes and reinforcing them at different points were 22 more reinforced-concrete tubes of the same diameter but of lesser length. Some of these served at certain stages of the sinking as man shafts and mucking shafts because it was necessary to excavate earth within the working chamber to permit the caisson to settle to its final position. The tubular walls were bound together by a reinforced-concrete deck, nearly 18 inches thick, which became the ceiling of the working chamber when the caisson was rotated 180°; and 29.5 feet below was a second deck, about 12 inches thick, which temporarily functioned as the bottom of the caisson when it was put overboard. The space between the two decks was subdivided by lengthwise and crosswise reinforced-concrete bulkheads that, besides giving added strength to the structure, formed a series of symmetrically arranged compartments. These were variously weighted with water ballast to help capsize the caisson after launching and to regulate its dead weight during subsequent operations. The water ballast could be forced from one compartment to another to hold the floating caisson on an even keel, or it could be discharged overboard to impart desired buoyancy. Compressed air was the motive medium that served to distribute or to expel the water. A series of pneumatic and hydraulic pipe lines, with suitable and accessible valves, were built into each caisson to facilitate this control. Also, there were vents, subject to manipulation, for the escape of pent-up air in different parts of the caisson at the time of tipping.

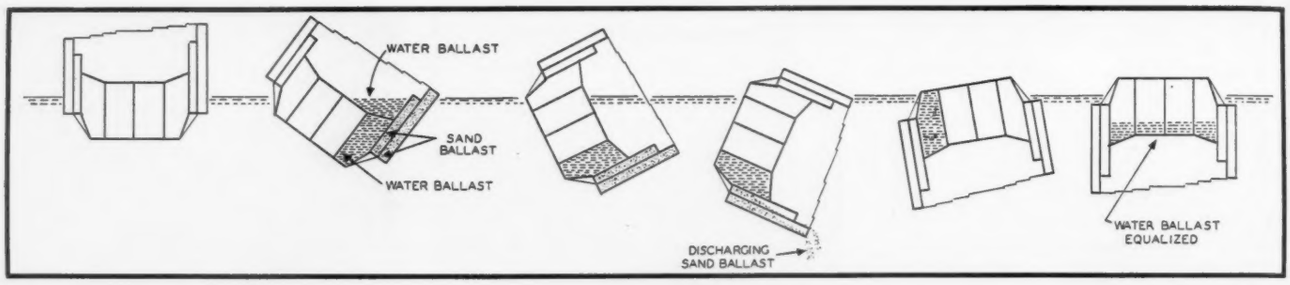
During construction, each caisson was supported by 180 closely spaced piles arranged in three longitudinal groups. Each pile carried a cylindrical and vertically sliding cap that was held at a uniform level by a cushion of sand within each cylinder—the escape of the sand permitting the cylinder, like an empty sleeve, to slip about 5 inches downward over the upturned end of the sustaining post. By this simple and ingenious means the finished caisson was shifted from the building blocks to the launching ways erected a few inches lower. Ordinarily, a ship is wedged up from her building blocks to transfer the load to the launching ways. These sand boxes were emptied





CAISSON AFTER LAUNCHING

At the left is a newly launched caisson showing some of the cylinders that compose its walls being filled with gravel to aid in overturning it. The plan drawing at the right illustrates the arrangement of the tubular walls and of the compartments.



OVERTURNING A CAISSON

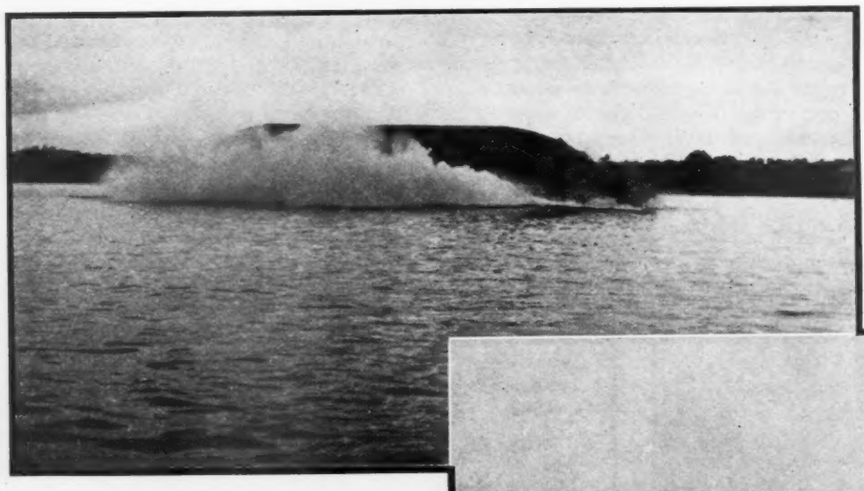
The caissons were built and launched bottom-side up, and were then turned over by shifting the center of gravity with ballast. The successive stages in the capsizing are sketched from left to right.

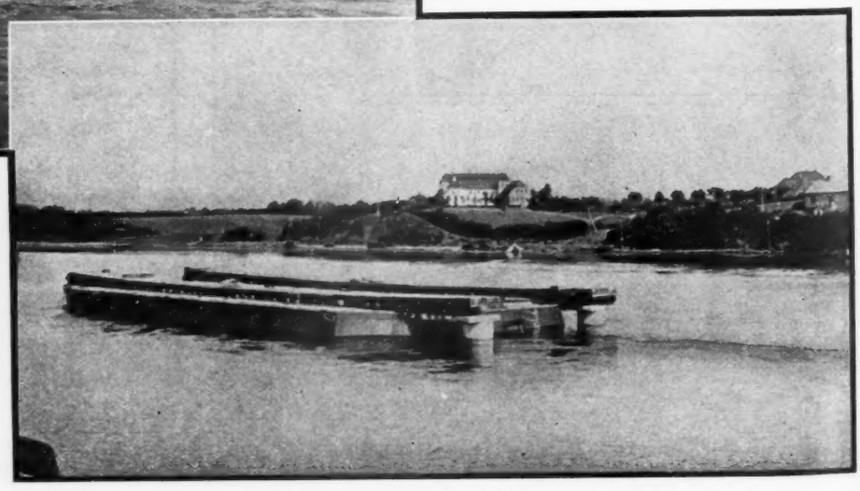
successively and uniformly in six groups so that the total dead weight of the caisson could be gradually placed upon the launching structure. The two sliding ways were secured to the underside of the caisson, and the groundways were supported by multiple lines of wooden piles driven deep enough into the ground to remain unyielding when the concentrated load of the caisson was brought to bear upon them during its travel from shore to deep water.

Each upturned caisson had a length of 147.5 feet, a breadth of 79 feet, and a maximum height of 62.33 feet. At its upper or rear end it was anchored to a massive block of concrete, buried in the ground, by two wire cables under a tension of 220 tons. As soon as these cables were severed by a cutting torch, the structure was free to move under its own impulse waterward—being brought to a standstill when afloat by heavy hawsers and blocks of concrete serving as a tripping device.

Capsizing was effected by filling a number of the circumferential tubes on the higher side with quite 780 tons of fine gravel and then admitting to seven compartments between decks and on the same side a total of 661 tons of water ballast. This gave the caisson a list of 30.5°. The heel was further increased by progressively taking in water above the deck or ceiling of the working chamber until the caisson was tipped sufficiently to allow water to pour in over the depressed tubular cutting edge and to start the capsizing or rotating movement. As this motion continued, a point was reached where the gravel ballast dropped automatically out of the tubes, lightening the caisson and bringing that side up to the surface of the Little Belt. At that stage, enough water ballast was forced by compressed air from the filled compartments into compartments on the opposite side to cause the caisson to float with its upturned deck level. The capsizing was done in water nearly 100 feet deep; and the maneuver was generally accomplished somewhat deliberately within an interval of 40 minutes—the climacteric plunge being spectacular and thunderous.

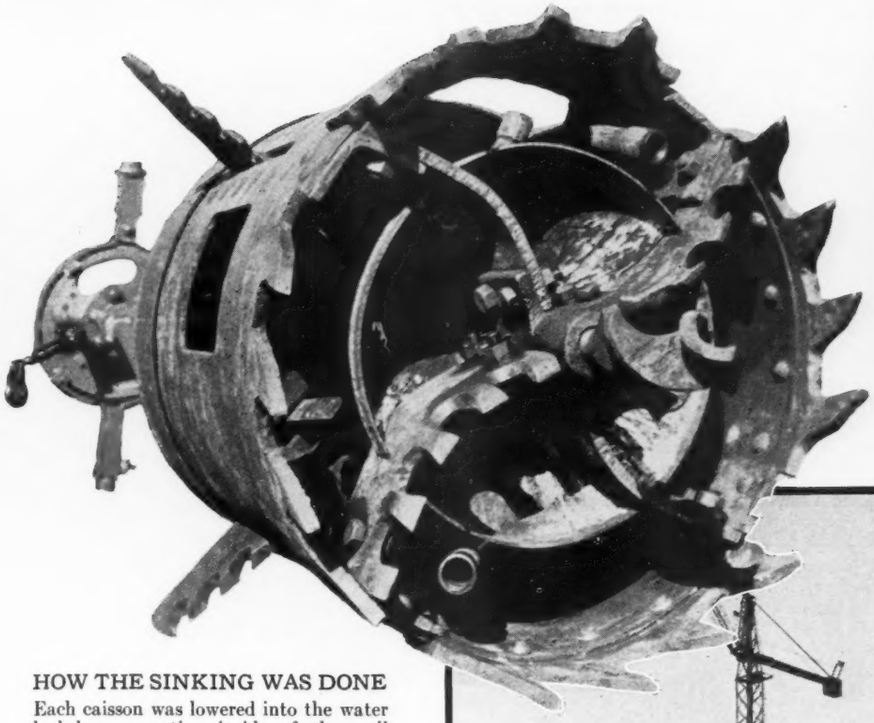
With the caisson floating in its designed normal position— that is, with the cutting edge down, it was towed to a point of suitable depth, loaded with water ballast, and sunk. The added dead weight was ample to cause the cutting edge to penetrate the bottom about 3 feet; and anchors further served to hold the caisson fast while several lifts of the concrete pier were poured on top of it. With this done, the water ballast was expelled with compressed air and the caisson made buoyant and towed to a second position in deeper water, where ballast was again admitted and the caisson once more brought to rest on the bed of the Little Belt. There more lifts were poured to heighten the pier, after which the caisson was towed to still deeper water where the pier was raised higher. At that stage the caisson could be made buoyant by the expulsion of water from the ballasted compartments; but by that time the structure as a whole had become sufficiently heavy to effect its sinking at the designated place with comparative ease and precision despite the sweep of the strong tidal currents that flow at different rates at two levels. When the caisson settled on the bottom, its cutting edge fitted that surface just like the cap of a tooth and its surmounting pier was high

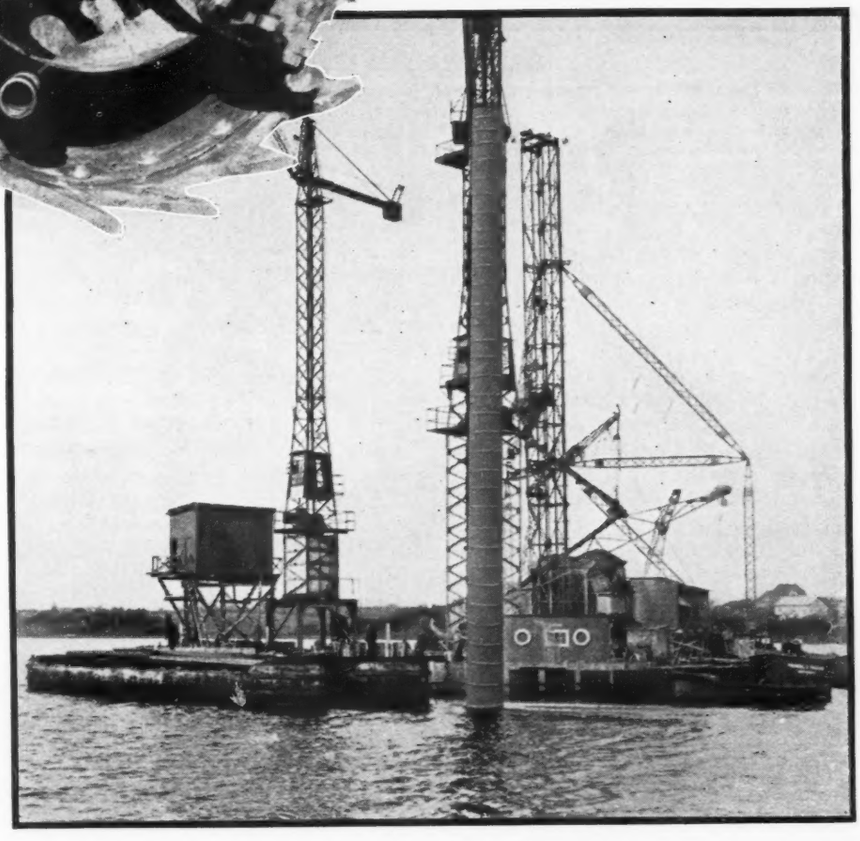




A GIGANTIC SPLASH AND THE RESULT

A caisson at the instant of capsizing (above). The entire overturning procedure in each case normally required less than an hour. At the right is an uprighted caisson in sinking position and with the launching ways still attached.





HOW THE SINKING WAS DONE

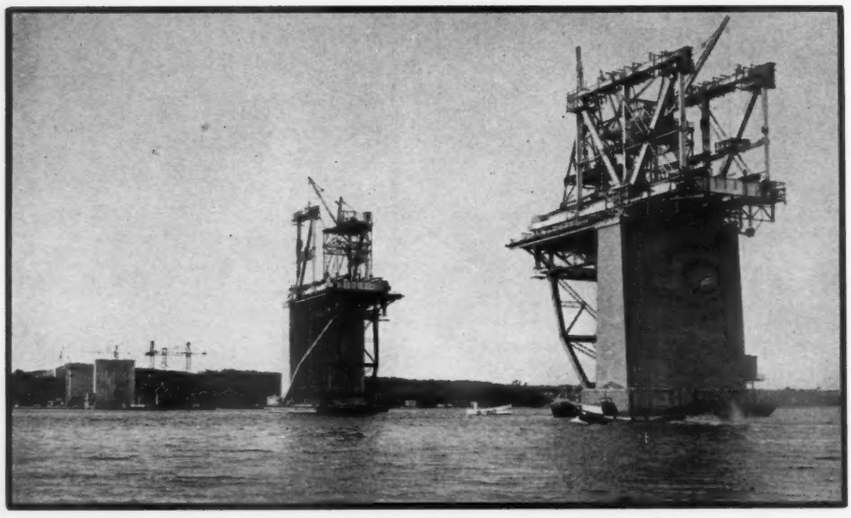
Each caisson was lowered into the water bed by excavating inside of the wall tubes. The special rotary tool with which this was accomplished is shown above. Lumps of clay loosened by the cutter were broken up with water jets, and the resulting mud was raised to the surface by air lifts. A long guide tube (right) served to direct the cutter down to the upper opening of each wall tube. After the cutting edges had penetrated the impervious clay a sufficient distance, the interior of the caisson was rendered watertight, and men were able to excavate the central areas in the dry and under atmospheric pressure. Although geological reports indicated that the waterway was underlain by clay alone, an occasional bowlder was encountered. These were removed through the wall tubes by means of grabs (upper right).

enough to project about 10 feet above the surface of the channelway.

Before describing the manner in which excavating was done beneath the cutting edge and within the working chamber so as to get the caisson down to its final seating, and in order to make that operation thoroughly understandable, something should be said about the nature of the water-bed formation. For about 300 feet down—with the exception of a top course, 8 feet thick, consisting of a mixture of gravel and small bowlders—it is a homogeneous mass of greasy clay of a highly compacted character. The geological experts had declared that no rock of a troublesome nature would be encountered; but on a number of occasions single bowlders of granite were struck as the caissons penetrated the water bed. It was necessary at times to send divers down to loosen them with powerful water jets, and then to bring them up to the surface with a grab bucket. The clay itself was readily removed with the facilities provided. After the cutting edge of a caisson had penetrated the clay for a depth of less than 15 feet, the formation became impervious and no water passed under the edge and into the working chamber. Because of this virtue, it was possible for workmen to descend into the chamber and to do the excavating under atmospheric pressure even though as much as 110 feet below the surface of the Little Belt.

The ground beneath the tubular cutting edge was removed by a special apparatus that operated in succession through each of the wall tubes of the caisson—care being taken to do this alternately on each side and at each end so that the structure would remain perpendicular while sinking. It was lowered from the surface to the upper portal of each tube through a long, suspended guide tube of corresponding diameter. There were several of the latter, and each was made of thin steel plating reinforced externally with rings of steel.

The excavator was composed of a steel cylinder, 37.4 inches in diameter, the lower edge of which was provided with cutting teeth of special steel. Within the cylinder, near the bottom, there was a 4-bladed concentric cutter also armed with teeth—the cylinder and the attached cutter being rotated by a hollow shaft extending to the driving motor at the surface. Projecting from the bottom of this shaft and reaching about a foot below the boring drum was a massive steel helix



THE COMPLETED PIERS

As the caissons were progressively towed and sunk, successive lifts of concrete were poured on top of them, so that, when they reached their final positions, the piers projected about 10 feet above the surface of the water. This view shows the starting of the steelwork on the five cantilever spans.

which served to center and to guide the excavator when penetrating the clay beyond the bottom edge of a wall tube. Two pipes, fastened to the hollow driving shaft but paralleling it outside, terminated at the 4-bladed cutter, and a third similar pipe terminated within a conical hood surmounting the cutter—the hood forming an open bell or funnel connecting directly with the open lower end of the driving shaft. Powerful water jets from two of the pipes broke up the clay lumps produced by the rotary cutters, and compressed air fed through the single main emulsified the mixture and caused the hollow driving shaft to function as an air lift in bringing the excavated material to discharging goosenecks on the working platform at the surface. At four points along the periphery of the drum, the cylindrical cutter was equipped with four extendable toothed cutters that could be used to enlarge the excavation made by the drum itself. Interposed at points vertically along the driving shaft were adjustable annular guides that steadied the shaft and kept it centered while in operation. The speed of penetrating the hard clay ranged from 0.8 inch to 1.57 inches per minute.

At two of the offshore piers, because of the sharp slope of the water bed, it was necessary to give the caissons a deeper hold than had been planned. Therefore, steel tubes of slightly smaller exterior diameter than the cutting-edge tubes, and ranging in length from 10 feet to 20 feet, were driven with a special 4,000-pound hammer into the clay below the bottom of the cutting edge—thus extending the penetration to a uniform depth of 132 feet below the surface of the water, or nearly 33 feet into the clay. This assured the desired added anchorage in the water bed. The wall tubes and the extended steel tubes were next excavated and thoroughly cleaned, after which all of them were filled with concrete by means of a bottom-dump bucket, of about 1 cubic-yard capacity, which automatically discharged when reaching the lower end of a tube, or the level of the previously deposited concrete.

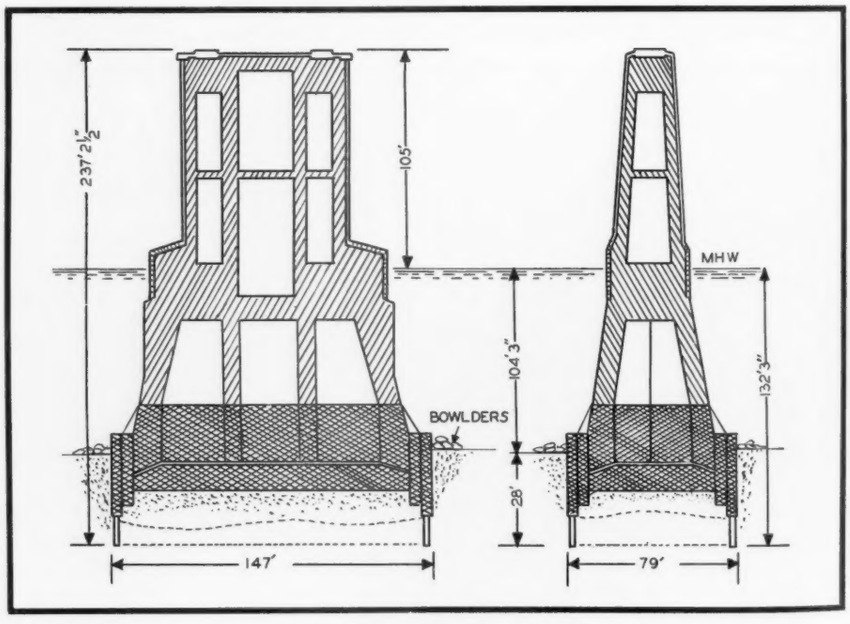
With a caisson at its final depth and the wall tubes filled with concrete, then the working chamber was excavated sufficiently to place concrete immediately beneath its ceiling to a vertical depth of 11.5 feet. This was done by digging a succession of narrow trenches from side to side of the working chamber and filling them with concrete one after the other to maintain at all times ample support for the ceiling. The clay was loosened with pneumatic spades and shoveled into skips that were hauled to the surface through a shaft installed for that purpose. A second shaft, with a ladder, provided a passageway for the workmen and also served as a ventilator. The concrete was delivered to the working chamber through a pipe line extending down from the surface working platform. Owing to the impervious nature of the penetrated clay, each working chamber remained dry during the period of excavation.

While the caissons were in process of sinking, the surmounting pier structures were continually heightened so as to keep their tops above water. When in position, and when certain of the interior subdivisions were filled with concrete, then work was concentrated on the raising of the piers to their maximum elevations. With the piers finished, the erection of the cantilever steel spans was taken in hand.

The Little Belt Bridge which links the dominating Peninsula of Jutland with the large Island of Fuenen has involved an outlay, so it is stated, of $8,000,000. The experts responsible for its building are to be highly commended for their ingenuity and their resourcefulness in skillfully overcoming many serious difficulties, which explain why it has taken almost seven years to consummate the undertaking.

The caissons on this job were designed, as already mentioned, by Monberg & Thorsen; the sinking of the caissons and the construction of the bridge piers were done by Gruen & Bilfinger, Mannheim, Germany; the bridge spans were erected by Louis Eilers, Hannover; and the structural steelwork was produced in the Rheinhausen plant of Friedrich Alfred Huette.

Photographs by courtesy of Gruen & Bilfinger, A. G., and Pieux Franki.

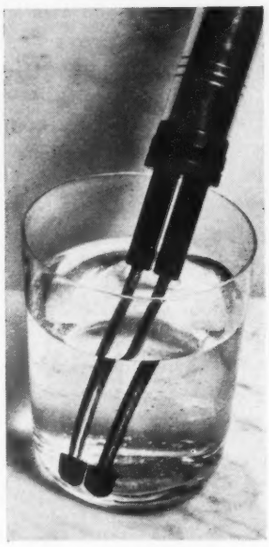


SECTIONS THROUGH PIER

The areas of heavier shading indicate the caisson.

Sterilizing Liquids with Silver in Solution

A. M. Hoffmann



IN CONVENIENT FORM

The pocket sterilizer assembled and in service. To obtain the desired results, the water must be stirred gently with the silver electrodes for from 40 to 60 seconds for each pint being treated and allowed to stand for about an hour, depending upon its physical properties and its germ content. After that it is safely potable and will remain so for a long time.

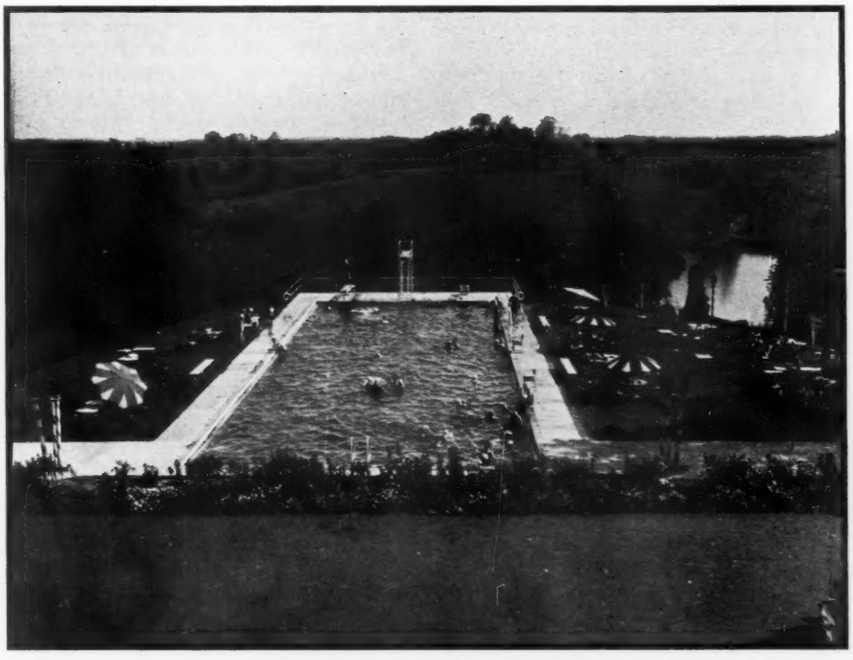
ENGINEERS, geologists, prospectors, explorers, campers, and others going far afield from dependable sources of water for drinking purposes should be glad to know that a little device is available which will enable them to keep themselves supplied with water free from harmful bacteria. The device is of pocket size, and does on a small scale what stationary equipment, of which it is a development, is now doing on a large scale. We refer to the electro-katadyn process of sterilizing liquids. It originated in Germany, and depends for its effectiveness upon the action of silver ions.

It has been known for years that the presence in water of minute quantities of certain metals, such as silver and copper, will bring about the destruction of any contained pathogenic bacteria and impart to it lasting germicidal properties. Only of late years, however, has this knowledge been put to practical use by Dr. G. A. Krause, of Munich, who, together with his coworkers, has succeeded in developing a process by which it is possible to introduce into liquids sufficiently small dosages of silver under conditions that will assure maximum bactericidal activity.

Without going into technicalities, the pure metallic silver required is in the form of electrodes, and low-voltage, direct current is used to effect its discharge into water or any other liquid constituting the electrolyte. In this way approximately 31 grains of silver are brought into solution per ampere-hour. As the quantity of metal passing from the electrodes into the liquid is proportional to the current flow, this discharge can be readily controlled by means of a simple resistance. Both the current and the silver consumption are negligible. In the case of large industrial plants, for example, the electrodes are renewed perhaps once a year and the current requirement is less than that of a modern radio set. The large swimming pool of the Congressional Country Club in Washington, D. C., which has been equipped with the electro-katadyn process of sterilization, takes no more current to purify its 150,000 gallons of water than does a 50-watt lamp. The amount of silver used and, incidentally, its cost, depend upon the quantity of water treated, and vary accordingly. The metal, of course, is not recoverable, which is a matter of considerable interest to the mining fraternity.

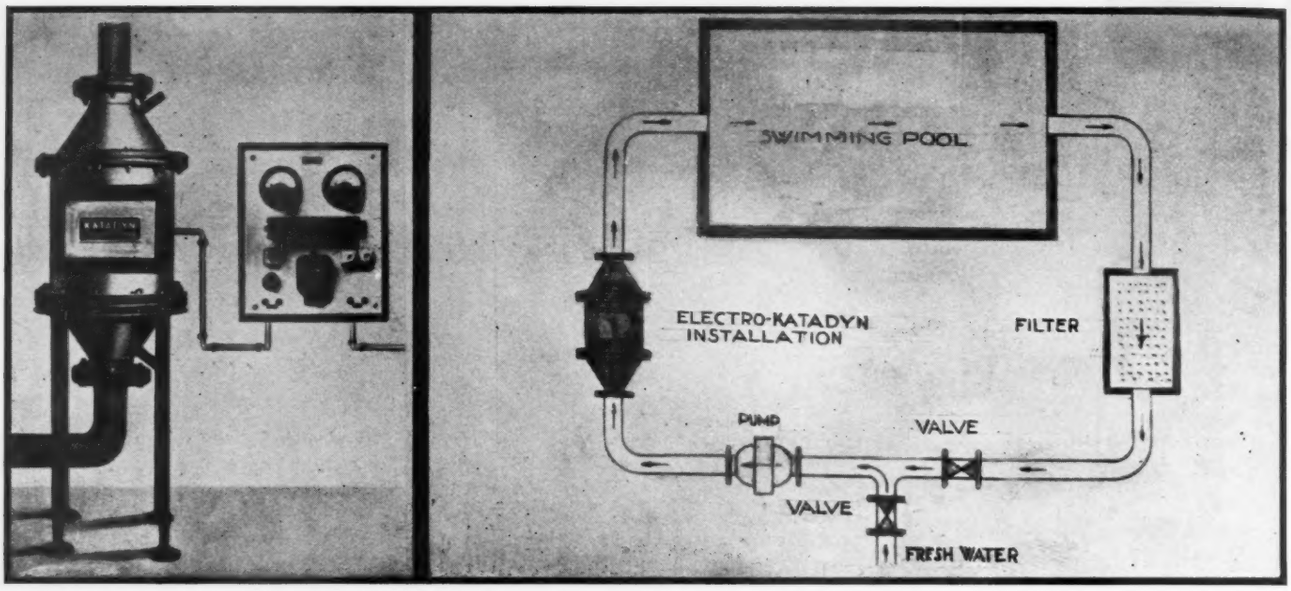
For commercial sterilization generally, the electrodes are contained in a metal pressure vessel through which flows the liquid to be purified This container is lined with a special insulating material which necessitates reversing the current at definite and short intervals in order to prevent the formation of anodic coatings of high resistance. This is done automatically. The handy pocket device, suitable for sterilizing as little as a glass of water, consists of a standard dry cell or cells housed in a metal cylinder to which the silver electrodes are attached when it is to be used—the several parts, for convenience, fitting into a leather case. The batteries, of course, have to be renewed periodically, but the apparatus itself will last a lifetime. Pressure filters for treating from 20 to 500 gallons hourly are also available. These possess none of the disadvantages of the type ordinarily employed in that there is no filtering medium to offer lodgment and breeding places for bacteria and therefore no need of cleaning them periodically by steaming or boiling.

The ionic silver does not kill the bacteria immediately. Depending upon the germ



SAFE FOR BATHERS

The Congressional Country Club swimming pool in Washington D. C., which is supplied with water sterilized by the electro-katadyn process. This is the first large-scale application of the method in the United States.



EQUIPMENT AND SWIMMING-POOL LAYOUT

The water on its way to the pool flows past electrodes consisting of a battery of silver plates spaced equidistant in a chamber in the pressure vessel at the left. The number and the area of these plates and the size of the chamber determine the degree of concentration of silver ions in the water. The system operates automatically, and not only rids the water of disease-breeding germs but imparts to it germicidal properties that safeguard it against reinfection.

content and the physical properties of the water, it may take one or several hours to effect sterilization. However, with this done, the water retains its germ-killing powers for a long period—in fact, it has been kept for more than a year in tightly sealed flasks without losing much of its germicidal potency. Liquids so treated do not change their taste, odor, nor color, and even a considerable overdose of silver is said to do no harm. Once installed, the equipment requires little or no supervision. There are no solutions to prepare and to control, no pipes and no valves to take care of, and there is nothing to corrode. For continuous operation it is necessary merely to adjust the voltage at suitable intervals and to renew the electrodes.

Although in its infancy here, the process is finding increasing application in diversified fields abroad, where it was introduced about two years ago. Water for swimming pools, for use in the manufacture of ice, and for washing hose, piping, filters, bottles, etc., in breweries and dairies, is being sterilized by this method, as is also the water supply of the City of Heidelberg and of the new German pocket cruiser *Königsberg*. Wine, fruit juices, and other liquids produced by fermentation are so treated to prevent cloudiness and the continued growth of microörganisms during storage. Among the latter is vinegar, of which something like 15,850 gallons are processed hourly in this manner in plants abroad in order that it may remain clear after filtering.

It has been found that alcohol solutions when charged with ionic silver undergo a change that is akin to aging. Already, perfumers are treating alcohol in this way, and experiments are now being made in order to determine whether or not the taste and odor of gin, brandy, whiskey, etc., can thus be improved.

Fly Ash Cleans Turbine Blades Well and Economically

CLEANING turbine generators in steam power plants is an operation of major importance. Steam carries with it over the turbine blades suspended matter, some of which adheres to them and gradually builds up a thin film of very hard scale. This, together with the accumulating dust, has to be removed when turbines, after a year or more of almost continuous service, are thoroughly overhauled to maintain efficiency.

Steel scrapers or sand-blasting are generally employed to do this work, but with varying measures of success. In the case of the former, hand labor is required as well as numerous sizes and designs of scrapers that conform to the differing shapes of the blades. The highly abrasive sand blast, on the other hand, effectually removes the scale, but it has a destructive effect on the metal. Acids also have been tried with unsatisfactory results; and pulverized coal was found to be lacking in hardness. The latter was applied with compressed air by means of a guniting machine; but while it cleaned all right it did not do it fast enough to meet the needs of the service.

Pressure blasting, in itself, is well adapted for the work, but what is essential is an abrasive that will remove the scale from the blades without damaging them. Apparently, such a material has been discovered in what is known as fly ash, a by-product of the combustion of pulverized coal. Fly ash is exceedingly fine, passing through a wire sieve having 40,000 openings to the square inch; and in the burning process the minute particles become hard and well rounded. It was first used in cleaning the rotor of a 50,000-kw. turbine, and, as in the case of the pulverized coal, was applied pneumatically and with the assistance of only two men. Not only did this abrasive do the work thoroughly, but it accomplished it in about half the time formerly required by scraping. In order to determine its cutting action, a blade was weighed on a laboratory scale before and after cleaning, and when the figures were checked it was found that less than 0.0005 inch of metal had been worn away in the process.

Judged by its performances, fly ash would seem to be superior to other means and methods commonly employed for this purpose. And, what is more, it effects considerable savings in that it is available in unlimited quantities in steam plants burning pulverized coal.

Raising Sunken Sections of Concrete Roads

Spalling Around Bottoms of Holes for "Mud-Jacking" Eliminated by Using New Core Drills

SECTIONS of concrete highways that are laid on top of fills composed of soft material occasionally sink below grade after they have been in use for some time. These local subsidences result from settlement of the supporting base material. Such low spots give rise to an undulating road surface which makes for "bumpy" riding. If the condition becomes aggravated, stretches of the highway may even become actual menaces to safe driving.

Moreover, unless corrective measures are taken before the settlement has progressed too far, the sections of concrete affected will eventually be destroyed. This is so because the sudden change in grade, even though it be slight, causes heavy trucks to exert upon the surface a pounding effect which tends to break it up. Also, the stresses which develop during the subsidence cause the concrete to crack, and consequently to hasten disintegration. All motorists are familiar with road sections of the type referred to.

Patching and building up sunken areas improve the condition, but the method is not considered a satisfactory solution of the problem. A more acceptable and effective way of eliminating such dips is to raise the pavement to its original height and to restore the subgrade beneath it. For some years both these things have been accomplished in one operation by what is known as the "mud-pump" or "mud-jack" system. This consists of pumping a mixture of loam, cement, and water underneath the pavement through holes drilled in it for the purpose. By taking one traffic lane at a time, these operations can be carried on without closing the road. The plastic mixture hardens in a relatively short time and forms a firm and lasting support.

It has been general practice in the past to drill the required holes with the "Jackhamer" type of rock drill. This is a quick and an inexpensive way of doing the work, but it has the objectionable feature of producing spalling around the 2½-inch-diameter holes when the drill breaks through the bottom of a concrete slab. Investigations have shown that these miniature inverted craters attain a width of from 12 to 18 inches and a depth of from 2 to 3½ inches. The spalling is more pronounced in the case of concrete made with gravel aggregates than in that made with limestone aggregates, but in either case it is extensive enough to be serious. As the holes are ordinarily spaced on 6-foot centers, the total spalling reaches such proportions as seriously to weaken the pavement.

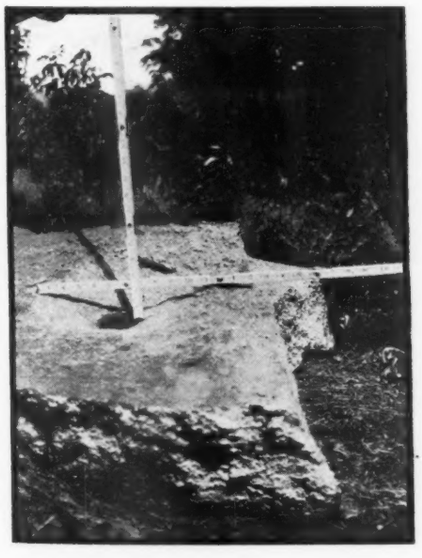
In an effort to find a more satisfactory means of drilling the holes, the Bureau of Maintenance of the Missouri State Highway Commission conducted a series of experiments which led to the conclusion that a portable, rotary drill employing steel shot as an abrasive would solve the difficulty. Designs for such a machine were sketched and submitted to Ingersoll-Rand Company, builders of "Calyx" core drills of which a certain type has long been in use for taking cores of concrete pavements for test purposes.

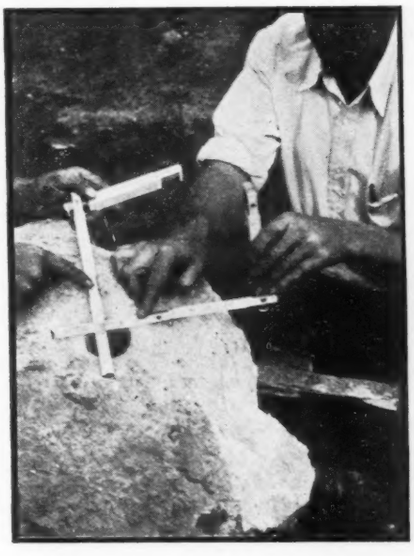
The drill that was developed for this special service is mounted on steel wheels. It is driven by a gasoline engine, which also furnishes propulsive power for moving the unit from hole to hole. This is particularly desirable where work is being done on a road section of appreciable grade. To facilitate maneuvering the machine, brakes and a steering wheel are provided, with all controls located convenient to the drill head. For long stretches a specially equipped truck is employed. It accommodates two drills. These, with the truck, constitute a working unit.

The results obtained with these machines fully came up to the expectations of the highway engineers; and they have been adopted as standard equipment for the work in question. The drills can, when desired, be used for other purposes, such as putting down holes for electric-light standards, guard-rail posts, and traffic markers, and for taking test cores of pavements. Although the service mentioned calls for holes 2½ inches in diameter, the drills are capable of boring holes up to 7½ inches in diameter. Their speed of drilling varies with the size of the hole and the nature of the concrete. In concrete made of limestone aggregate, they will average an inch of 7½-inch hole per minute.

Accompanying comparative pictures clearly show that the spalling which occurs when a rotary drill is used is very much less than when a percussion type of drill is employed. The reason for this reduction is at once evident. The pounding of the bit in the case of the conventional rock drill naturally tends to break away material from around the hole as it nears the penetration point. The rotary drill, on the other hand, exerts a cutting effect that is obtained through the abrasive action of ground shot carried around a circular slot beneath the edge of the bit, which is in the form of a hollow pipe section.

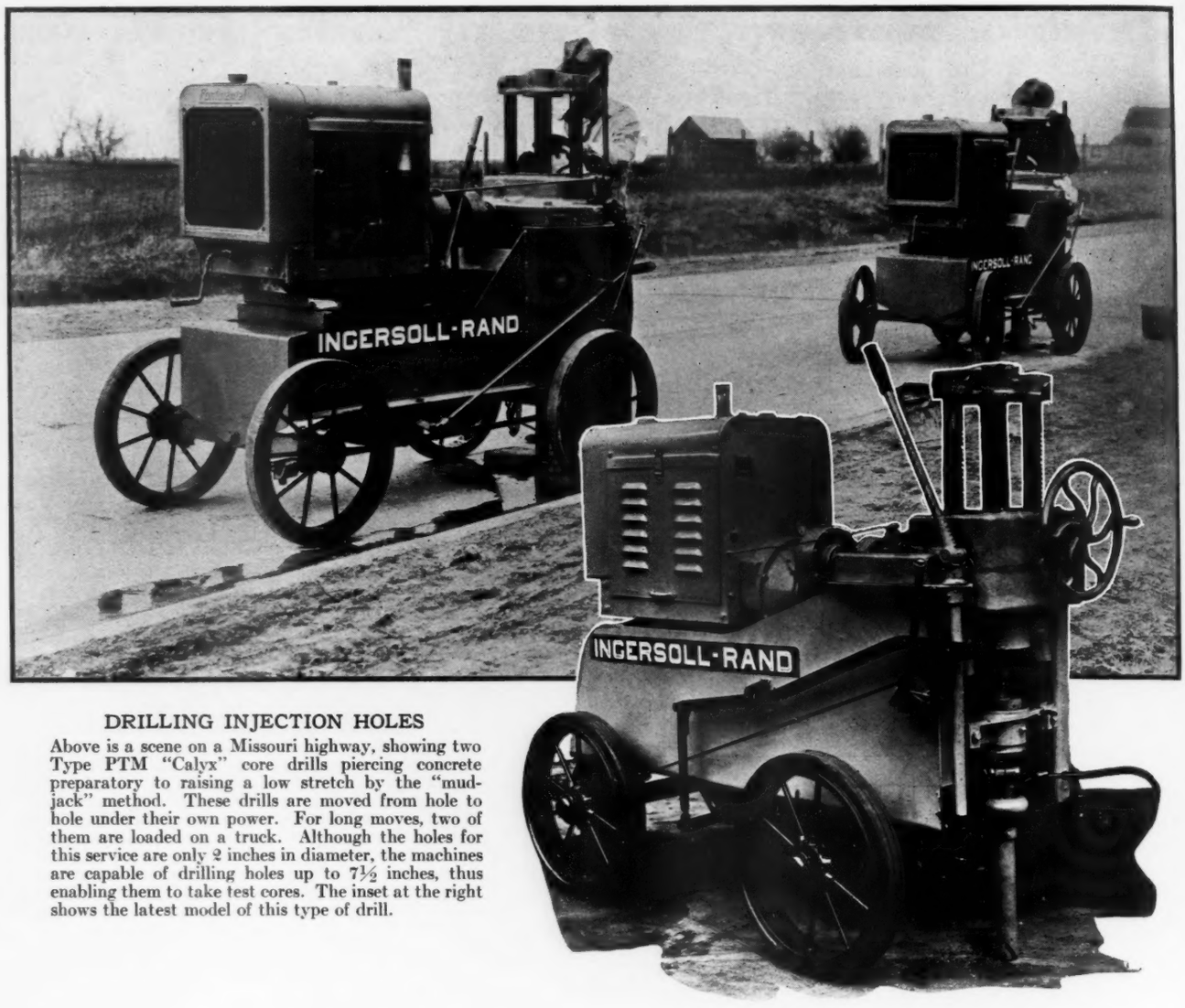
To equalize conditions as nearly as possible in an effort to get comparative results, the final drilling with the rotary machine was done with the full weight of the tool column on the bit. In actual practice, the operator eases up the pressure on the bit when nearing the penetration point, and it has been demonstrated that this further reduces the tendency to spall. It does not slow up the cutting speed—in fact, it has been found that the shot drill cuts faster when pressure less than the maximum is applied. The holes made by this type of machine are straight, round, and smooth walled; and when operators become experienced, there is virtually no spalling around the bottom.





COMPARISON OF SPALLING

The picture at the left shows the underside of a section of concrete that was drilled with a percussion rock drill. Note the large quantity of material that spalled off when the drill bit broke through. On the right is a similar specimen that was drilled with a core drill. The small amount of spalling evident can be eliminated by easing the pressure on the bit when the hole is nearing completion.



DRILLING INJECTION HOLES

Above is a scene on a Missouri highway, showing two Type PTM "Calyx" core drills piercing concrete preparatory to raising a low stretch by the "mud-jack" method. These drills are moved from hole to hole under their own power. For long moves, two of them are loaded on a truck. Although the holes for this service are only 2 inches in diameter, the machines are capable of drilling holes up to 7½ inches, thus enabling them to take test cores. The inset at the right shows the latest model of this type of drill.

In order to determine relative costs of the new and the old methods of doing the work, the Missouri State Highway Department ran some tests with "Jackhamer" drills and also kept an accurate record of expenses of shot-drilling covering an extensive period of operations. The indicated cost of "Jackhamer" drilling was computed to be 20 cents per hole. Because of the limited duration of the tests, this figure may not be accurate, but it is believed to be fairly representative for various types of pavement. The average cost of drilling with a shot drill was found to be 37.7 cents per hole. In arriving at it, expenses chargeable to drilling were tabulated from daily field reports and pay rolls extending over a period of five months during which 58,681 holes were drilled. The items that entered into this cost record included salary and expenses of field foremen; wages paid laborers; truck rental (five cents a mile operation and six cents a mile depreciation, or a total of eleven cents a mile); and core-drill rental (55 cents an hour operation and 30 cents an hour depreciation, or a total of 85 cents an hour). Operating costs covered fuel, oil, repairs, tires, grease, replacement parts, and, in the case of the core drills, also steel shot, bits, and tools. The depreciation rates were fixed at a point which contemplated retirement of the purchase price of the equipment during its service life. Supervision and overhead were not included in the cost data.

The cost of 37.7 cents per shot-drill hole is the average for all the holes, which were put down in four different kinds of concrete pavement. The average cost per hole in each of these varied as follows: gravel-aggregate concrete, 64.8 cents per hole; reinforced-gravel-aggregate concrete, $1.12 cents per hole; limestone-aggregate concrete, 25.8 cents per hole; reinforced-limestone-aggregate concrete, 41.9 cents per hole. The depth of the holes ranged from 6 to 7 inches in the central parts of highways to 9 inches along the edges, and the rate of drilling ranged all the way from 7.3 minutes per hole in plain limestone-aggregate concrete to 28.5 minutes per hole in reinforced-gravel-aggregate concrete.

The idea of using rotary drills was suggested by C. P. Owens, of Jefferson City, Mo. Mr. Owens is maintenance engineer for the Missouri State Highway Department. His conclusions regarding the cost and general effectiveness of the core drill in this class of work are:

"Since it is common practice to drill a line of holes along each edge of pavement and one along the center, spacing holes six feet apart, a hole is drilled for each four square yards of pavement to be raised. When the cost of "Jackhamer" drilling is 20 cents per hole, the cost per square yard of pavement is 5 cents. When the cost of drilling with rotary drills is 40 cents per hole, the cost per square yard of pavement is 10 cents. This additional cost is but a small proportion of the total cost of raising concrete slabs with "mud-jacks", and one which seems to be fully justified when the benefits of obtaining true, round holes with no spalling of the bottoms of slabs are given due consideration."

COOLING DEEP MINES

THERE seems to be ample warrant for the statement that millions of dollars will be spent during the next few years in the installation of equipment for cooling the air in the deeper workings of the South African gold mines. The limit at which human beings can carry on is rapidly being approached, and the problem of alleviating temperature conditions is right now one of the paramount considerations of mining men on the Witwatersrand. The Village Deep Mine has an extreme depth of 8,800 feet below the surface, and there rock temperatures range as high as 96°F. Some of the other mines are nearing corresponding depth and heat. Moreover, the high temperatures are accompanied by high humidity, which accentuates the discomfort of the workers. All in all, conditions are bordering on the intolerable, and mining concededly cannot progress very much deeper unless artificial cooling is introduced.

There is no question that the problem will be met, for the prize at stake is exceedingly rich. Although the reef that now produces, roughly, 50 per cent of the world's gold shows definite evidence of flattening with increasing depth, its lowest limits are still far below the deepest working levels. What is more important, the ore apparently persists in the deeper horizons, and its gold content is well maintained. One authority has calculated that for every 200 feet existing workings are extended downward there can be mined $100,000,000 worth of ore. As the rock temperature rises one degree for every additional 200 feet of depth, the value that can be placed upon a one degree reduction in mine temperatures is, accordingly, $100,000,000 in recoverable gold.

Ventilation of workings, together with the use of huge quantities of ice at so-called hot spots, has thus far permitted work to be continued, but these resources will no longer suffice. Mine owners are therefore prepared to spend up to 25 cents per ton of ore crushed on effective cooling equipment. In the case of the larger mines it is contemplated investing as much as $500,000 in the plant itself and up to $200,000 or $300,000 annually in its operation. The method by which the air can best be cooled and dehydrated is yet to be determined. The two principal means now under consideration are: refrigerating plants and compressed-air systems.

The surface air in that region has a mean temperature of 60°F. and an average relative humidity of 50 per cent, the dew point being 41°. Typical summer and winter temperatures are, respectively, 73° and 41°; but in the deeper mine workings the temperature and humidity are almost the same the year round. In order to reduce the humidity of the surface air before sending it underground, it is plain from the foregoing figures that it must be cooled below 41° under average conditions. In winter the dew point is often 16°, so that cooling to that point is required to drop out water.

A surface refrigerating plant now being installed at the Robinson Deep Mine is designed to cool 400,000 cfm. of mine intake air to a saturation temperature of 32°. This will be done in three stages, and it is expected that about 14,000 gallons of water will be taken out of the air each day in summer. With the usual commercial refrigerants, such as ammonia, the location of refrigerating plants is virtually restricted to the surface because of the dangers attendant upon the possible escape of the gas.

Compressed air will produce the desired effects, and is free from the objections that apply to refrigerating systems. One scheme that has been advanced is to compress air at the surface, devaporize it, and send it underground. There it will be used for ventilation after first being expanded, and consequently cooled, in air motors which will drive fans, compressors, pumps, rock drills, and other essential equipment. By the means sketched, it is practicable to obtain discharge temperatures far below zero. The outstanding virtue of compressed air is that it will liberate a sufficient supply of fresh, cool, dry air in the working zones where it is most needed, where it will be of greatest benefit. A book describing such a system is reviewed on the following page.

★ ★ ★

WORTHY OF THEIR HIRE

PROBABLY the most satisfying pay that anyone can receive for his efforts is the knowledge that he has done a good job. As a fitting recognition of superior craftsmanship, the New York Building Congress annually presents certificates of award and small gold medals to those workmen that show outstanding abilities in their lines. The awards are made in connection with the larger building enterprises; and during the past ten years they have been received by 2,951 workers on 150 structures. They go not only to skilled artisans but also to common laborers. When building activity was brisk, there were as many as 500 awards a year, but fewer have been distributed of late.

Selections are made by a subcommittee composed of a member of the craftsmanship committee of the congress, the architect of the structure, the owner, the builder, and a representative of labor. Presentation ceremonies are held in the building just before its completion and in the presence of all the workmen.

The awards were instituted to impress upon the workmen and the public that, despite the widespread application of machinery in construction, the part played by human beings is indispensable. In discussing the basis of the awards, William O. Ludlow, chairman of the craftsmanship committee, stated: "A good craftsman realizes that good buildings are produced by cooperation all the way down the line from the owner to the laborer, and he rightly feels that his part in the work is just as important as the architect's or the contractor's; he is proud to point out the buildings he has had a hand in erecting. Superior craftsmanship is just as important today as it was in the Middle Ages."

Cooling Deep Mines with Compressed Air

As is pointed out on the editorial page, one of the most pressing problems facing the South African gold-mining industry is the necessity of removing heat and humidity from the lower mine workings. A scheme for accomplishing this purpose by the utilization of compressed air has been devised by two members of the engineering staff of the Anglo-American Corporation, one of the large operators on the Rand. These gentlemen, Messrs. S.E.T. Ewing, M.I.E.E., M.I.Mech.E., and A.L. Egan, A. M.I.Mech.E., have presented their plan in a 46-page booklet, *Mine Cooling by Devaporised Compressed Air*, published by Radford, Adlington, Ltd., at Johannesburg, South Africa. A review of that publication follows. It was prepared by Frank B. Doyle, B.S. (Eng.), M.S., M.E.

AS MAN pursues veins of ore deep into the earth, its exploitation becomes more and more difficult. The reason therefor is not primarily the existence of increased transportation costs, earth pressures, pumping problems, etc., but, rather, the mine atmosphere, which becomes progressively less and less tolerable. The intolerableness is a matter of temperature and humidity and not of devitalization.

The authors divide the causes of increased temperature at great depth into two parts: "man-made heat" and heat radiated into workings from the rock. The principal sources of man-made heat are auto-compression of the ventilating air as it descends deep shafts; the mechanical equivalent of all energy supplied to the underground workings, except that which is used for hoisting, and even then the losses of the motors and hoists (15 to 20 per cent) appear as heat; heat emitted from the bodies of the miners, from explosives, from lamps, etc.

At present some heat is removed from the mines by the ventilating air. As the workings grow deeper, and more electrically operated machinery is installed underground, larger and more powerful ventilating fans are required to move a sufficient amount of air to carry away a given portion of the heat. This method of dealing with the problem has a physical limit: the air as it passes down the shaft compresses itself by virtue of its own weight (auto-compression) and experiences a corresponding temperature rise. Assuming a surface temperature of 75° F., and no evaporation *en route*, the temperature at the bottom of a 7,000-foot shaft would approximate 112° F.

The problem of removing heat from a deep mine is surrounded by the following restrictions and conditions not usually encountered in air-conditioning problems:

1—There is a vertical distance of from 5,000 to 7,000 feet between the area to be conditioned and the place where the heat can be rejected, for ultimately the heat must be discharged to the atmosphere at the surface. This condition makes underground refrigeration units highly undesirable, except in special cases, because of the pumping and pressure problems involved.

2—A conventional air-conditioning apparatus installed at the surface to condition the entire volume of air entering the mine is seriously handicapped by the long and tortuous shafts and passageways through which the air must travel and be "protected" on its way to the workings and by the inevitable loss caused by auto-compression.

3—The amount of heat to be removed from the mine is approximately constant throughout the year; and even though the power required for the operation of the conditioning equipment may be less in winter than in summer, continuous operation is necessary. In conditioning hotels, office buildings, warehouses, etc., on the contrary, the apparatus seldom operates more than half the year. Consequently, a higher cost of installation is justifiable in the case of mine conditioning if a lower operating cost can be obtained thereby.

This book points out that "It is logical to assume that the first step in combating mine heat is to refrain from adding heat from any avoidable source, and it is considered that the second step should be the provision of coldness at as many strategic points as possible and in as large quantities as possible." In accordance with these premises, the authors propose:

1—To substitute air motors for electric motors wherever possible. The air supplied to the air motors having been previously dried (devaporized) at the surface*, and the motors themselves being operated on full expansion, the exhaust from the motors will be both dry and cold: and if it is delivered to the working areas via ducts, improved conditions will result. Thus the mine atmosphere gains twice: first, the electrical losses of the motors (heat) are eliminated; second, the "coldness" of the exhaust will at least equal the mechanical equivalent of the energy supplied, regardless of the efficiency of the air motor.

2—To supply devaporized compressed air to the rock drills, thus reducing the relative humidity at the working faces even though the temperature remains the same and even though the present type of rock drill is used. (Reviewers note: With saturated compressed air, as is usually supplied to a rock drill, the exhaust port will freeze shut if the drill is designed to operate on an appreciable amount of expansion. When dry air is provided, the designer will be able to produce a drill that will operate satisfactorily with 50 per cent cut-off, thereby assuring "coldness" as well as dryness at the working faces.)

3—To reduce the ventilating air forced from the surface to the statutory quantity of 30 cfm. per man thereby reducing the heat produced by auto-compression.

As an introductory measure, "A simple way of reducing the heat entering a hot mine by a not inappreciable amount is to devaporise the compressed air produced on the surface for supplying the mine. The vapour heat so removed definitely represents less heat discharged into the mine wherever the compressed air is used and irrespective of how it is employed."

The authors discuss at some length three types of expanding air motors: The piston-and-cylinder, which is the most efficient; the turbine, which is lower in first cost per brake horsepower delivered but poorer in efficiency; and the sliding-blade eccentric-drum type, which falls between the two others in characteristics.

Having devised a method of obtaining cold, dry air at the working faces, and having discussed the various types of expanding engines available, it remains "to consider what work can be found for devaporised compressed air to do. Work on a mine can be divided into three essentially distinct types:

(a) The lifting of a weight, water, ore, etc., against gravity—that is, the production of potential energy.
(b) The performance of work which subsequently appears as heat, such as electric lighting, level haulage, scraping ore, driving fans.
(c) The generation of electric power, which may or may not be used to do work under types (a) and (b).

"The greatest net cooling is achieved when work is done against gravity, type (a), by expanding devaporised compressed air and exhausting it underground, with or without intermediate electrical machines. Such work is ideal for mine cooling, because air heat is converted into potential energy and coldness directly produced.

"If work of type (b) is done, with or without intermediate electrical machines, there is a heat balance in the mine and heat

*The authors consider that it is essential to remove the water vapor (steam) from compressed air, and to do this at the surface of the mine for the following reasons:
(1) To reduce the heat taken into the mine by an appreciable amount.
(2) To obtain the full cooling effect of expanding compressed air against a load, such cooling effect being seriously reduced by the condensation of any vapor which is not removed before expansion.
(3) To insure that the formation of ice and snow during expansion will not hinder the continuous operation of any type of air motor.

NATIVE "BOY" DRILLING WITH A "JACKHAMER" IN A RAND MINE

is neither removed from the mine nor added to it (except that the heat in the vapour in the displaced saturated upcast air is removed from the mine), whereas if such work, type (b), be done directly by electrical machines underground, as at present, heat is added to the mine equal to the *total* electric input.

"If work of type (c) is done, as, for example, the production of the considerable amount of electric power for the surface plant, by means of air motors either located underground or transmitting the exhaust air underground, the mine is cooled by the heat equivalent of the whole of the electric units generated.

"It follows, therefore, that the cheapest mine cooling by means of devaporised compressed air is obtained by doing work against external loads by air motors direct and by using pistons and cylinders when other factors are not prejudicial."

A thorough discussion of the practicability of the various applications and types of equipment involved is entered into separately. A comprehensive study of the operating cost of each is presented, together with the underlying theory. The following advantages are claimed for mine cooling with devaporized compressed air:

"The system differs from all refrigeration proposals in that the heat carrier ex mine is air which by its nature is a valuable acquisition underground, whereas liquid carriers are not.

"The initial capital cost is confined to the provision of the surface devaporising equipment, the cost of which is approximately 15 per cent of the original capital cost of the air compressors.

"Any further capital expenditure embarked upon for the expansive utilization of the improved compressed air is definitely proportional to the cooling effect obtained, and may therefore be incurred in small successive increments. The ultimate total of capital expenditure is defined entirely by the economic aspects of the increased efficiency of labour as ascertained from time to time."

Anyone interested in mine-atmosphere conditioning can well afford a careful study of this book. The authors show an unusual mastery of the subject, not only by the arguments they have presented but also by the pitfalls they have avoided. Mine cooling by devaporized compressed air offers a practical solution of a very difficult problem.

Difficulties of the Roadbuilder

ROADBUILDING in mountainous regions has its hazards under ordinary circumstances, but when the unexpected happens the workers are sometimes called upon to display the agility and daring of acrobats. That is just what occurred recently in the Yellowstone National Park in the case of a highway-improvement job. At one point the road skirts a precipitous cliff, and was widened by cutting back into the cliff about 11 feet and forming a half tunnel. However, when 1,650 tons of rock came crashing down on to the highway from the ledge, safety dictated scaling off the face of the overhang as far back as the inside edge of the road.

The work was done by drilling and blasting and, for the most part, was accessible only from the top of the cliff, which ranged from 80 to 140 feet in height. Two men were assigned to the job, and they had to be suspended by ropes and otherwise held in place so that they would be free to use their hands. From their perilous positions they drilled vertical holes from 8 to 12 feet deep on 2-to 4-foot centers. As all the material brought down had to be reclaimed, the holes were loaded lightly. Twenty were shot at a time; and two days were spent after each blast in scaling off loose rock and in cleaning up.

The portable compressor that supplied the air for the drills was stationed about 150 feet back from the working site, and the air line was run to the center of the slide area and thence up the cliff for a distance of approximately 70 feet. This line was tapped at suitable points by lengths of rubber hose connected to the drills.

The menace to traffic was thus safely removed, except for the damage done to a 20-foot-high rock embankment along the outer edge of that particular stretch of the highway. This had to be rebuilt. It had withstood the shock of the cave-in; but gradually gave way under the repeated impacts of the falling rock during the drilling and blasting operations. More than 9,500 tons of rock was brought down in easy stages on a 16:1 slope terminating at the inner edge of the roadway. The work was done under the supervision of C. F. Capes, engineer in charge of construction in Yellowstone National Park.

Industrial Notes.

Holes, cracks, or similar leaks in air, water, or oil tanks and the like can be repaired quickly, it is claimed, by the use of a plug introduced by the Multi-Seal Manufacturing Company, Chicago, Ill. It consists essentially of an anchor bolt, of a piece of ductile lead alloy that is of approximately the same diameter as the bolt

head, of a square washerlike piece of the same lead alloy, and of a hexagonal nut. To seal a leak, the entire plug is inserted, bolt head foremost, through the hole until the washer, let us say, comes in contact with the outer surface of the container. The nut is then taken up with a wrench, the resulting pressure causing the soft lead immediately back of the bolt head to collapse—to spread throughout a given surface inside the container and to fill up the hole around the shank of the bolt. The Multi-Seal Plug, as it is called, is said to withstand temperatures up to its own fusing point of 900°F. and a pressure of 2,000 pounds.

A shipment of 1,500 pounds of monel-metal rivets was recently returned to a manufacturer because it contained a few steel rivets. Picking the latter out by hand after letting them get rusty, as is sometimes done, was a prohibitive procedure because of the smallness of the rivets and the large number involved. Magnetic separation as usually practiced was also out of the question on account of the magnetic properties of monel metal. The problem was solved by heating the lot to 200°F., at which point monel metal loses its magnetic properties and steel retains it. Separation was thus easily effected.

Greater uniformity in foundry sands is assured through the adoption of standard specifications resulting from investigations made jointly by the U. S. Naval Gun Factory and the U. S. Bureau of Standards. Foundry sands now purchased on bids must in each case be the equivalent of reference samples which are kept at the Bureau of Standards. The physical properties of these controls are known; and, besides, each specification gives methods of sampling and testing. The aim, of course, is to bring about a standardization of molding practices and, in the last analysis, a general improvement in castings.

To the long list of preservatives against corrosion has been added still another that is claimed to give a high degree of protection to structural steel and masonry exposed to gases, liquids, moisture, etc. The product is a mixture of bituminous compounds and of a granular mineral aggregate, and is called Asphaltic-Guncrete. It is applied in two or more coats, approximately $\frac{1}{16}$ inch thick all told, by pneumatic equipment on the order of the cement gun. The first coat is described as being penetrating, adhesive, and elastic, while those that follow provide the necessary resistance to mechanical injury.

Making coal give off heat without burning it sounds like black magic; but it is done, and is explained by the fact that dark colors absorb heat from the sun more readily than do light ones and therefore radiate more heat. And what useful purpose does this serve? Russian farmers are said to speed up the maturing of their cotton crops by a month and more by spreading a thin layer of coal dust over their fields, using about 100 pounds to the acre. In the daytime it stores up heat in the underlying ground, thus making for a higher average temperature not only during the hours of night but during the entire growing season.

The U. S. Department of Commerce reports the development, in Germany, of a new method of copper-plating aluminum that dispenses with the use of electricity. The process, as described, consists of placing the aluminum, after it has been highly polished with an abrasive, in a cleaning bath that serves at the same time as a preliminary copper-plating bath. In this the oxide coating is removed from its surface and a thin film of copper deposited thereon. The metal is rinsed in water and rubbed until dry with a woolen cloth, leaving the copper red in color. Next it is immersed in the real copper-plating bath, and there it remains until the desired thickness of film has been obtained. The bond between the metals is claimed to be a firm one, and the material can be further processed without danger of the plating peeling off.

Marmon-Herrington Company, Inc., of Indianapolis, Ind., builders of all-wheel-drive trucks and truck-tractor equipment, have a mobile machine shop that is said to be the largest and most complete thing of its kind. It consists of a 6-wheel tractor and of a large semitrailer carrying everything required to do the company's ordinary repair work in the field. Besides the necessary small tools and instruments, its equipment includes a motor generator set, an air compressor together with an assortment of pneumatic tools, a pump and water-storage tank, an electric welder, a heavy-duty drill press, a universal milling machine, a heavy-duty lathe, a bench grinder, a steam vulcanizing outfit, a portable blacksmith shop, and a tent, 80 feet long and 45 feet wide, to house the shop at the working site.

Color has recognized value as a means of identification, and as such it is being made use of by a leading manufacturer of valves so that air, steam, hot- and cold-water, gas, and other service lines can be easily distinguished. But this is not the only innovation offered by him: the other is a 2-piece valve wheel consisting of a base and snap-on cover that is said to remain cool to the touch. These parts are molded of different plastic materials which, together with the form of construction, assure a tight joint. The wheels come in five standard colors—blue, red, black, green, and gray—and can be furnished either unmarked or, for further identification, suitably lettered in relief. Wheels for other special requirements can be provided in any desired color and with prescribed markings. Wherever there is

more than one valve to be manipulated, this new product of Jenkins Brothers has a field of application; and because the valves do not become hot, are pleasing in appearance, and can be made to harmonize with any color scheme, they are also well adapted for use in homes on fine plumbing and heating installations.